AD-A166 204 PULSED CHEMICAL LASER TECHNOLOGY DEVELOPMENT CRITICAL DESIGN REVIEW(U) AVCO EVERETT RESEARCH LAB INC EVERETT MA 05 MAR 84 DAAH01-83-C-0282 1/1

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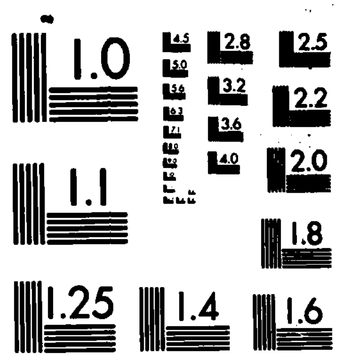

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AD-A166 204

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PULSED CHEMICAL LASER TECHNOLOGY DEVELOPMENT

INVENTORY

1

CRITICAL DESIGN REVIEW

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AD-A166 204

PULSED CHEMICAL LASER TECHNOLOGY DEVELOPMENT

CRITICAL DESIGN REVIEW

Contract No. DAAH01-83-C-0282

3/5/84

Prepared For

Department of the Army

U.S. Army Missile Command

Redstone Arsenal, Alabama

Prepared By

Avco Everett Research Laboratory

Everett, Massachusetts

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MICOM - PCL - CRITICAL DESIGN REVIEW

AGENDA

PROGRAM REQUIREMENTS / OBJECTIVES	9:15-9:30
J. MORAN	
STATUS OF SYSTEM MODIFICATIONS	9:30-10:00
J. MORAN	
SPECIAL PERFORMANCE DIAGNOSTICS	10:00-10:45
B. VU	
DATA ACQUISITION	10:45-11:00
N. OROZCO	
LABORATORY TOUR	11:00-12:00
LUNCH	12:00-12:30
REPETITIVE PULSE POWER DESIGN	12:30-1:15
C. PIKE	
PULSE POWER IMPLEMENTATION	1:15-1:45
V. N. MARTIN	
TEST PLAN	2:00-3:00
J. MORAN	

REQUIREMENTS FOR ARMY APPLICATIONS

CLOSED SYSTEM:

BLOW DOWN: CHEMICAL PUMP (Lithium)

RECIRCULATING: LITHIUM SCRUBBER (LiF or NaF)

SOLID GRAIN GAS GENERATORS:

F_2 (FROM NF_4 B F_4)

D_2 (FROM ND_3 B D_3)

N_2 (FROM N_A N_3)

TWO COLOR OPERATION:

DF 3.8 μM

DF → CO_2 10.6 μM (9.6 μM)

SCOPE OF TECHNOLOGY DEVELOPMENT

TASK I: ANALYSIS

- KINETICS AND LASER PHYSICS
- MEDIUM QUALITY
- FLOW SYSTEM ANALYSIS
- SCALING ANALYSIS

TASK II: SELECTION DESIGN AND FABRICATION

- CONFIGURATION CHARACTERIZATION
- CONFIGURATION DEFINITION
- PERFORMANCE DIAGNOSTICS
- TEST PLAN
- Today PDR - CDR
- FABRICATION AND ASSEMBLY

TASK III: DIAGNOSTICS AND PERFORMANCE TESTING

- SINGLE PULSE TESTING
- REPETITIVELY PULSED TESTING
- DATA ANALYSIS AND CORRELATION

TASK IV: SCALABILITY DESIGN/ANALYSIS

- CONCEPTUAL DESIGN

TEST CONFIGURATION REQUIREMENTS

	REQUIRED	PROPOSED
(FUEL VOLUMETRIC EFFICIENCY e_ℓ (j/ℓ)	20-50 j/ℓ	≤34 j/ℓ
PULSE LENGTH τ_P	1-10 μsec	1-10 μsec
PULSE RATE ν	25 pps	0-30 pps
RUN DURATION	1-5 sec	0-1.6 sec * Limited by F_2 on-line capability
CAVITY VOLUME	≥20 ℓ	** 22.5 ℓ
CAVITY PRESSURE	≤1.0 atm	150-760 torr Jet Pump (N_2 Driven)

CONFIGURATION ELEMENTS

GAS VALVING AND MIXER SYSTEM

LASER CAVITY

INITIATION SYSTEM (REP. PULSE)

OPTICS

ACOUSTIC SUPPRESSOR

DIAGNOSTICS

* Typically will run ~ 18 pulses or ~ 0.6 sec

** 22.5 liters for RP
30 " " single pulse

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TEST MATRIX PARAMETERS

- CAVITY PRESSURE
- DF AND DF → CO_2 MODES
- DILUENTS: HE, N_2, AR, NF_3, SF_6
- STABILIZER: O_2
- GENERATOR PRODUCTS: NF_3, CF_4, N_2
- SEEDANTS: SF_6, NF_3
- INITIATION LEVEL

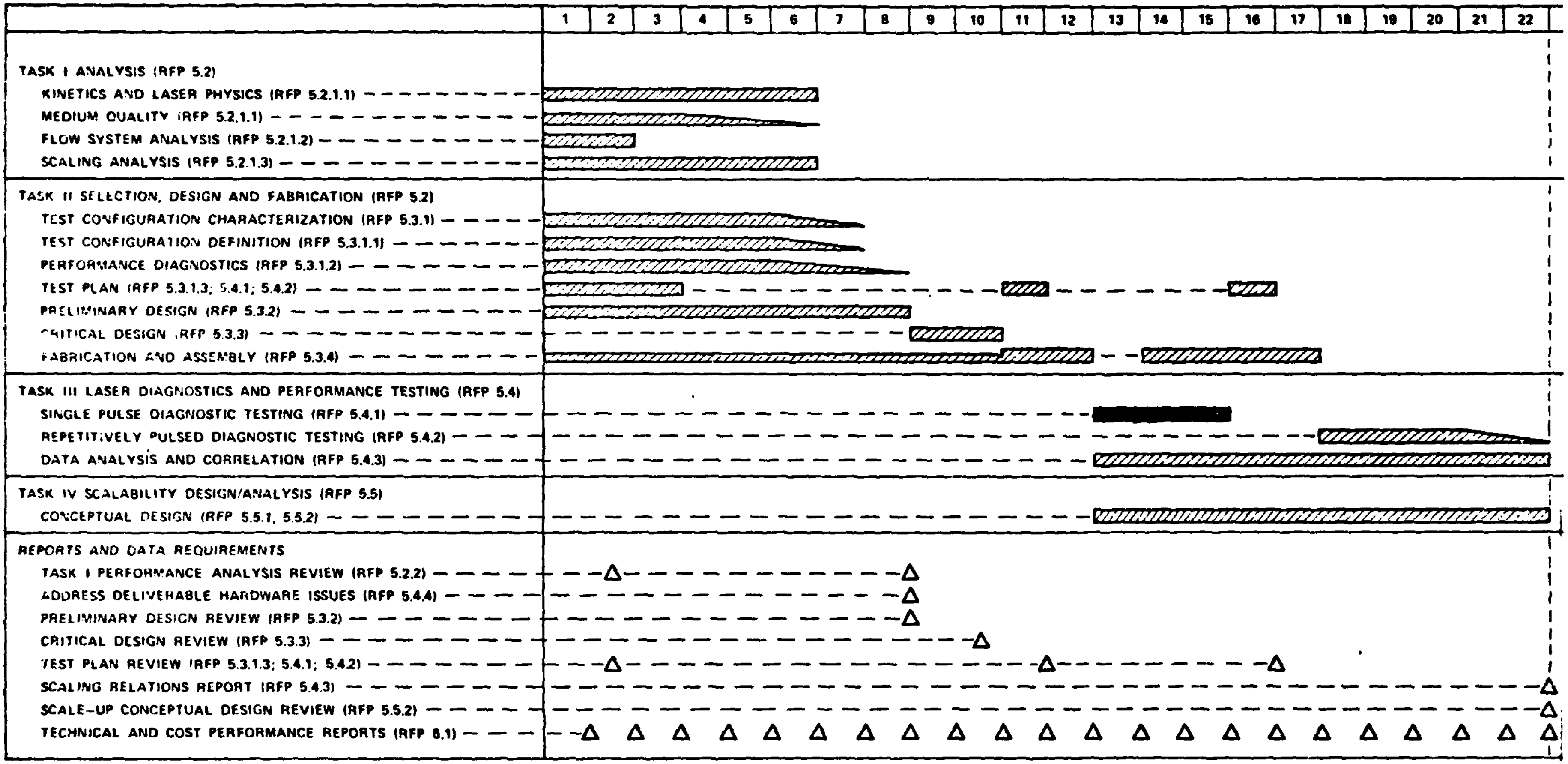
DIAGNOSTICS TO DETERMINE

- ENERGY PER PULSE
- PULSE SHAPE
- → TIME DEPENDENT SPECTRA
- INITIATION SYSTEM CHARACTERISTICS
- → F_2 DISSOCIATION LEVEL
- TIME DEPENDENT PRESSURE AND TEMPERATURE
- MEDIUM HOMOGENEITY
- ⇒ TIME DEPENDENT GAIN

MODELING IS REQUIRED TO SUPPORT THE ABOVE

- KINETICS (P.S.I./AERL)
- E-BEAM DEPOSITION (AERL)
- ACOUSTIC RECOVERY (AERL)

MICOM-PCL PROGRAM SCHEDULE



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AERL-PCL FACILITY

ELEMENT	MODIFICATIONS IN MICOM PROGRAM	
	SINGLE PULSE	REP PULSE
FLUIDIC VALVING	YES	NO
GAS MIXER	NO	NO
LASER CAVITY	NO	NO
ACOUSTIC SUPPRESSOR	NO	NO
FLOW CHANNEL STRUCTURE	YES	NO
JET PUMP	YES	NO
GAS SCRUBBER	NO	NO
E-BEAM FOIL AND SUPPORT	NO	YES
CATHODE	YES	NO
PULSE FORMING NETWORK	N.A.	YES
MODULATOR	N.A.	YES
FACILITIES	NO	NO
OPTICS TRAIN STRUCTURE	YES	NO
* OUTPUT WINDOW	NO	NO
DIAGNOSTICS AND CONTROLS	YES	YES

* For CO_2 operation, will put calorimeter inside optics box & use small ZnSe window to remove small portion of beam for diagnostics

For DF operation, will use large CaF_2 window to transmit beam from the cavity.

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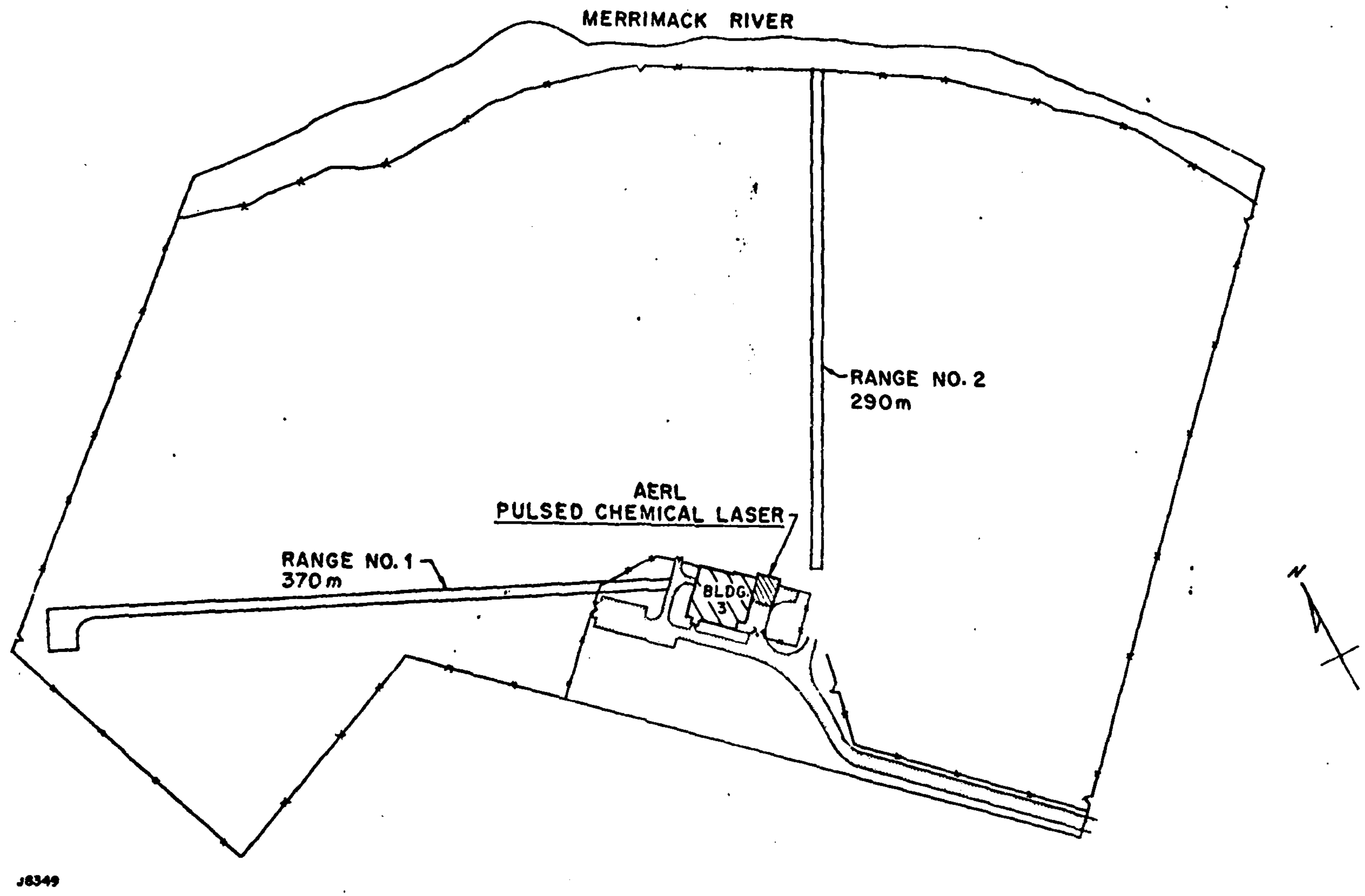
HAVERHILL FACILITY



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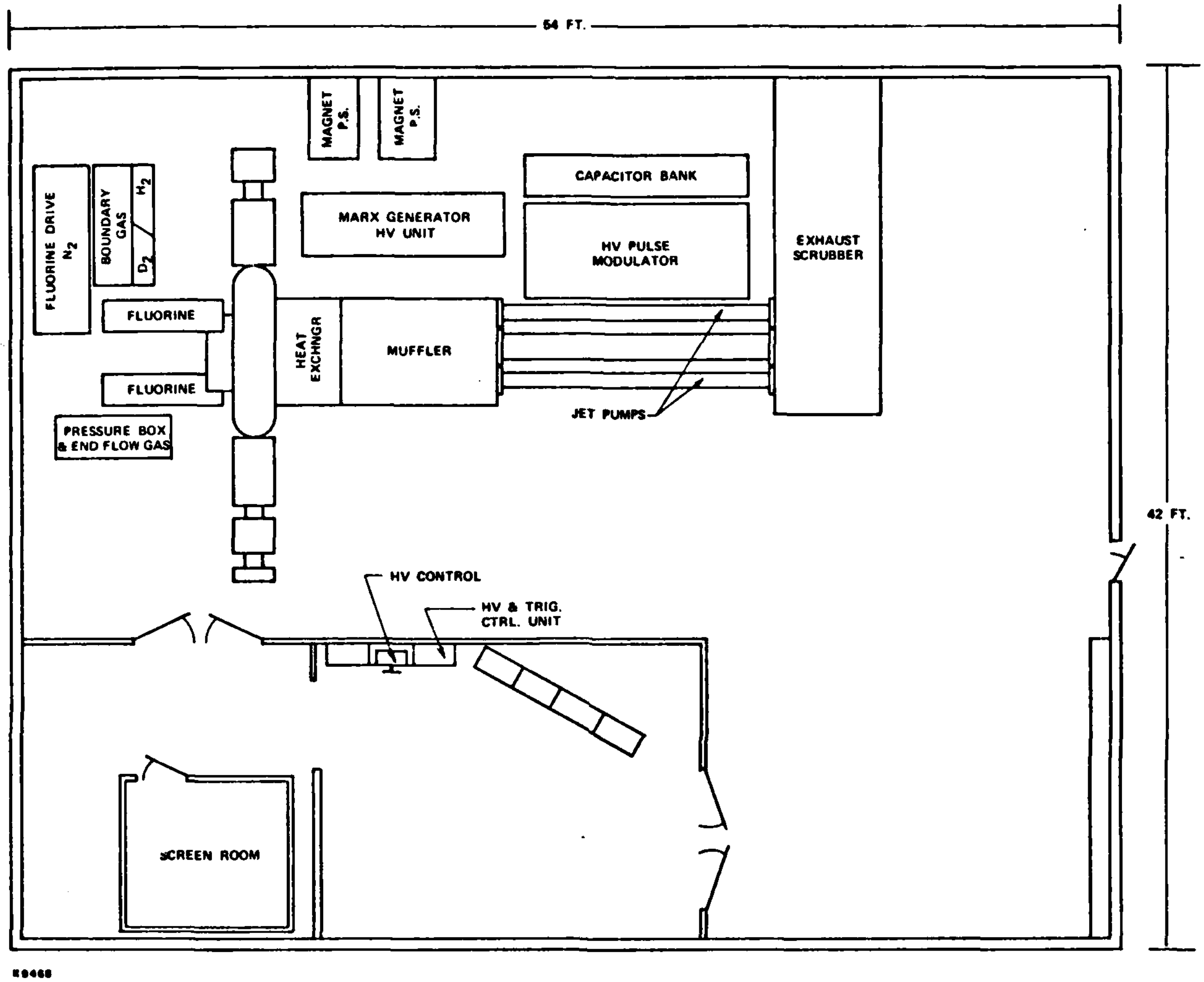
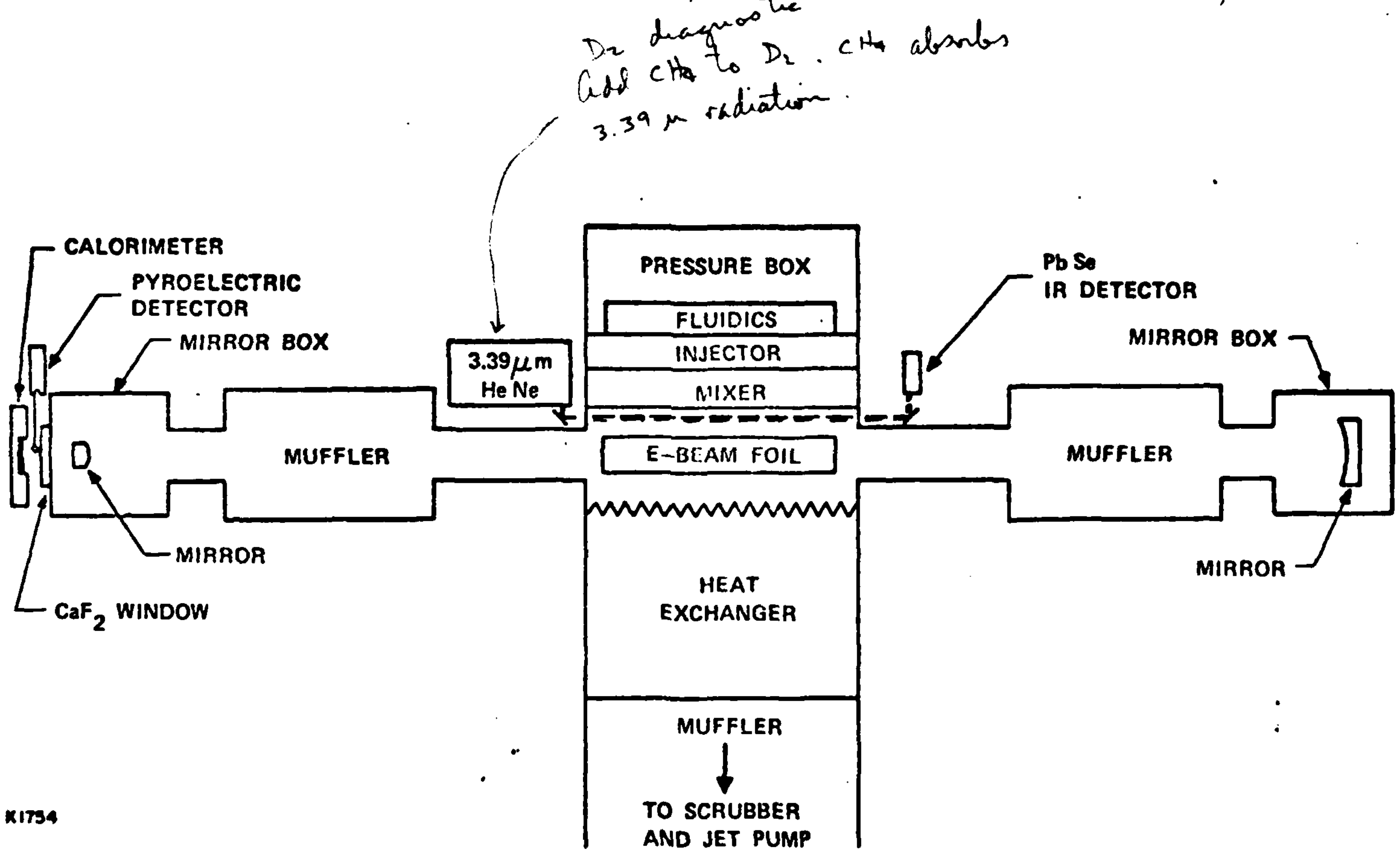


Figure 2.3.2 AERL-PCL Facility Floor Plan

SYSTEM COMPONENTS - PLAN VIEW

Flow thru Cavity is TOP to BOTTOM



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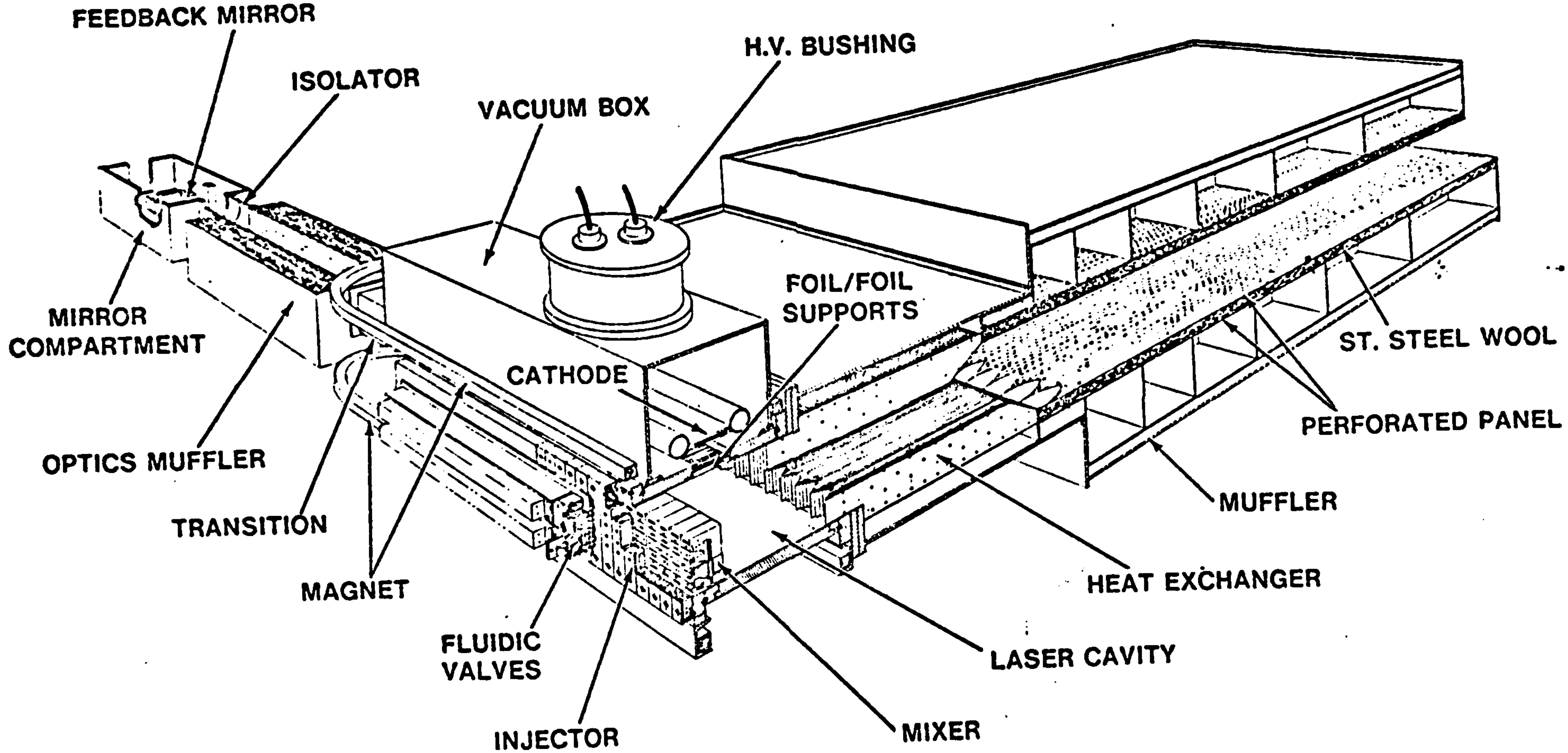
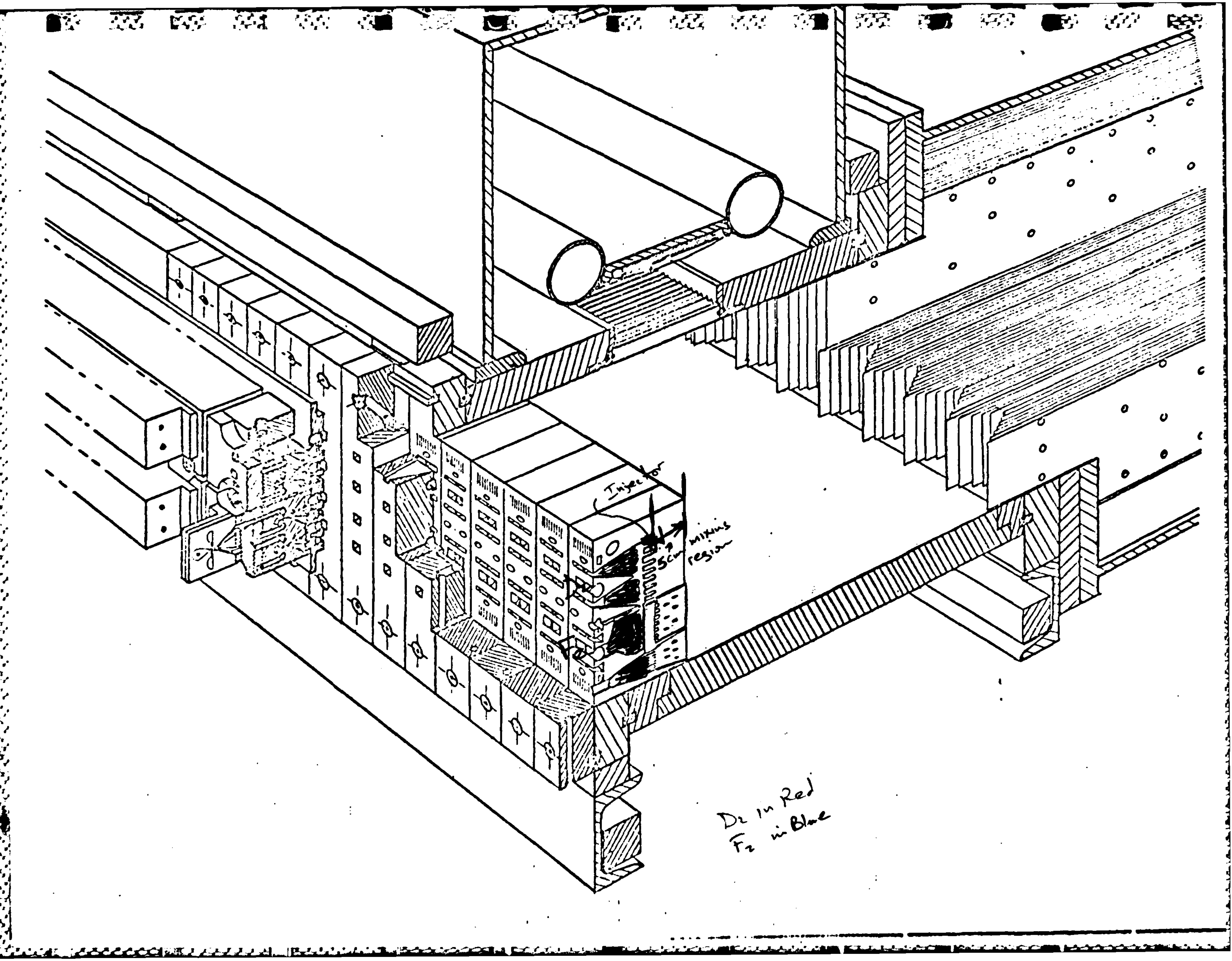

FEEDBACK MIRROR
ISOLATOR
VACUUM BOX
H.V. BUSHING
MIRROR COMPARTMENT
FOIL/FOIL SUPPORTS
CATHODE
ST. STEEL WOOL
PERFORATED PANEL
OPTICS MUFFLER
MUFFLER
TRANSITION
MAGNET
HEAT EXCHANGER
FLUIDIC VALVES
LASER CAVITY
INJECTOR
MIXER

K8074



Injector
mixing region
5cm
D2 in Red
F2 in Blue

STATUS OF SYSTEM MODIFICATIONS

ELEMENTS INITIATED AT START OF PROGRAM.

VALVE ASSEMBLY UPGRADE (AERL P-699-SECT 4.3.1.1.1)

TASK COMPLETED

FLOW TESTING IN PROGRESS.

CATHODE MODIFICATIONS (P-699-SECT 4.3.1.1.3.1)

FABRICATION COMPLETED

INSTALL AND TEST 3/19/84 After 1st single pulse testing. ~~Will baseline w/ old cathode~~ for comparison w/ previous data.

ELECTRON GUN MODIFICATIONS. (P-699-SECT 4.3.1.1.3.3)

FOIL SUPPORT DESIGN COMPLETED for RP testing

FABRICATE BY 4/9/84

BUSHING MODIFICATIONS COMPLETED 4 prong receptacle for RP testing

CABLE TERMINATIONS FABRICATION IN PROGRESS

CRYOPUMP AND ADAPTER FLANGES IN HOUSE to increase ~~pumping speed~~ for RP operation

FOIL DESIGN (P-699-SECT 4.3.1.1.2.4) for RP operation

3 MIL KAPTON 1/2 MIL AL FOIL IS IN HOUSE. 1/4" on center support Plan to try 3/8"

4 MIL KAPTON 1.0 MIL AL FOIL TO BE ORDERED. Backup if thinner foils fail

(Takes ~ 2 hrs to replace foil)

OPTICS AND EXHAUST FLOW SYSTEMS MODS (4.3.1.1.4.1-4.3.1.1.5.1)

MODIFICATIONS ARE COMPLETED

FLOW TESTING IS COMPLETED.

OPTICS TESTING - WEEK OF 3/5/84

STATUS OF FLOW TESTING

NO CAVITY GAS FLOW:

AT 1000 PSI JET PUMP DRIVE PRESSURE

CAVITY PRESSURE ≤ 180 TORR

FULL CAVITY GAS FLOW:

AT 1200 PSI JET PUMP DRIVE PRESSURE.

CAVITY PRESSURE ≤ 250 TORR.

GOAL OF (.20 ATM F_2, .06 D_2, .02 O_2) = 213 TORR

CAN BE MET. may require more O_2 for stability @ low diluent

CAVITY PRESSURE IS CONSTANT TO ± 7%

THROUGH THE RUN.

ALL GAS SYSTEMS ARE OPERATING

FLOW CONTROL SYSTEM IS OPERATING.

SPECIAL DIAGNOSTICS GAS HANDLING IS INSTALLED

HCl & HF seedant flows for diagnostics are installed

FLUIDIC VALVE SWITCHING TESTS 3/5/84 week of

FLUORINE FLOW TESTS 3/5/84 "

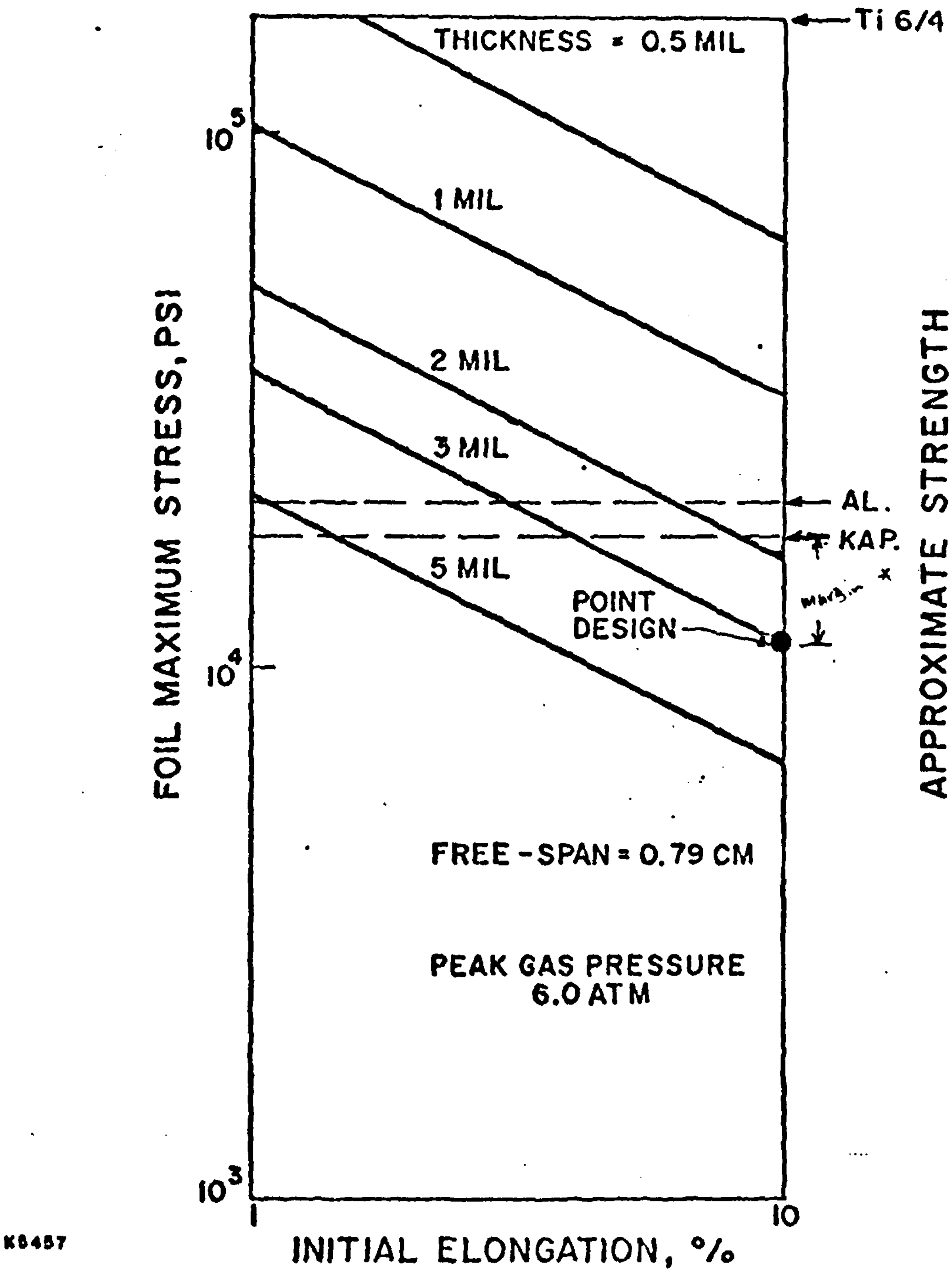


Figure 2.5.1 Stresses in Performed Foils

* Does not include heating.
If temp goes to 300°C, may
have to go to 4-mil foil

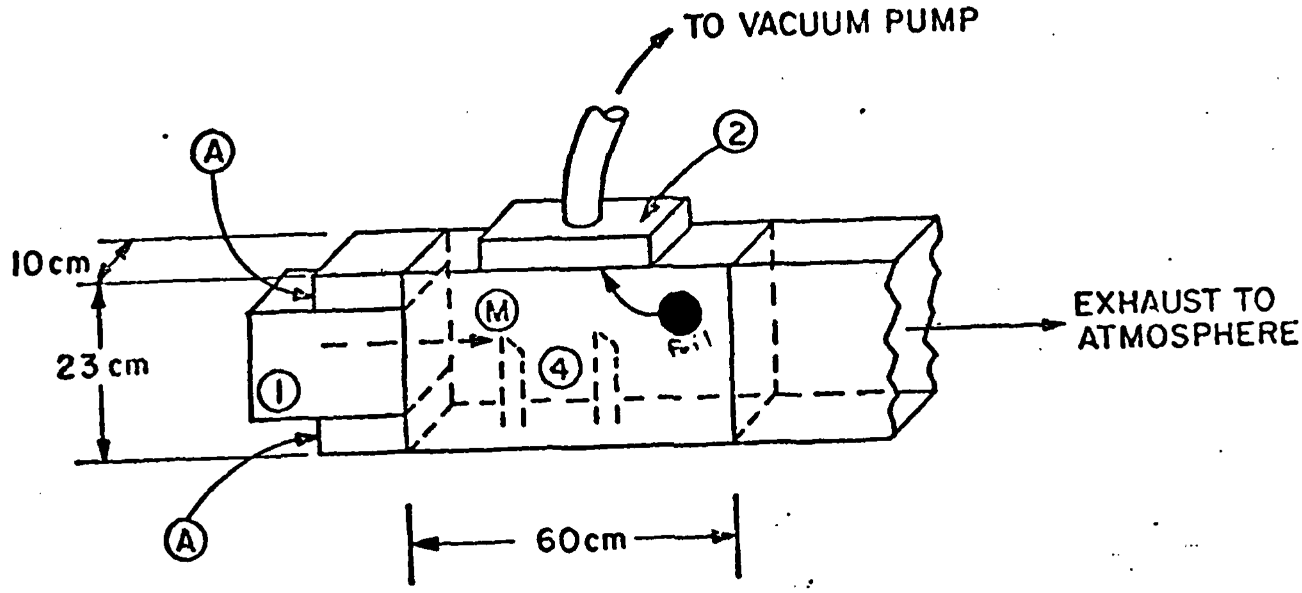


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Figure 2.5.2 Sketch of Foil Fatigue Test Set-Up
A : Air Boundary Flow
M : H_2/Air Mixture Flow
1 : Valve and Mixer System
2 : Foil Holder and Foil Support Structure
3 : 10 x 30 cm Foil
4 : Spark Plugs

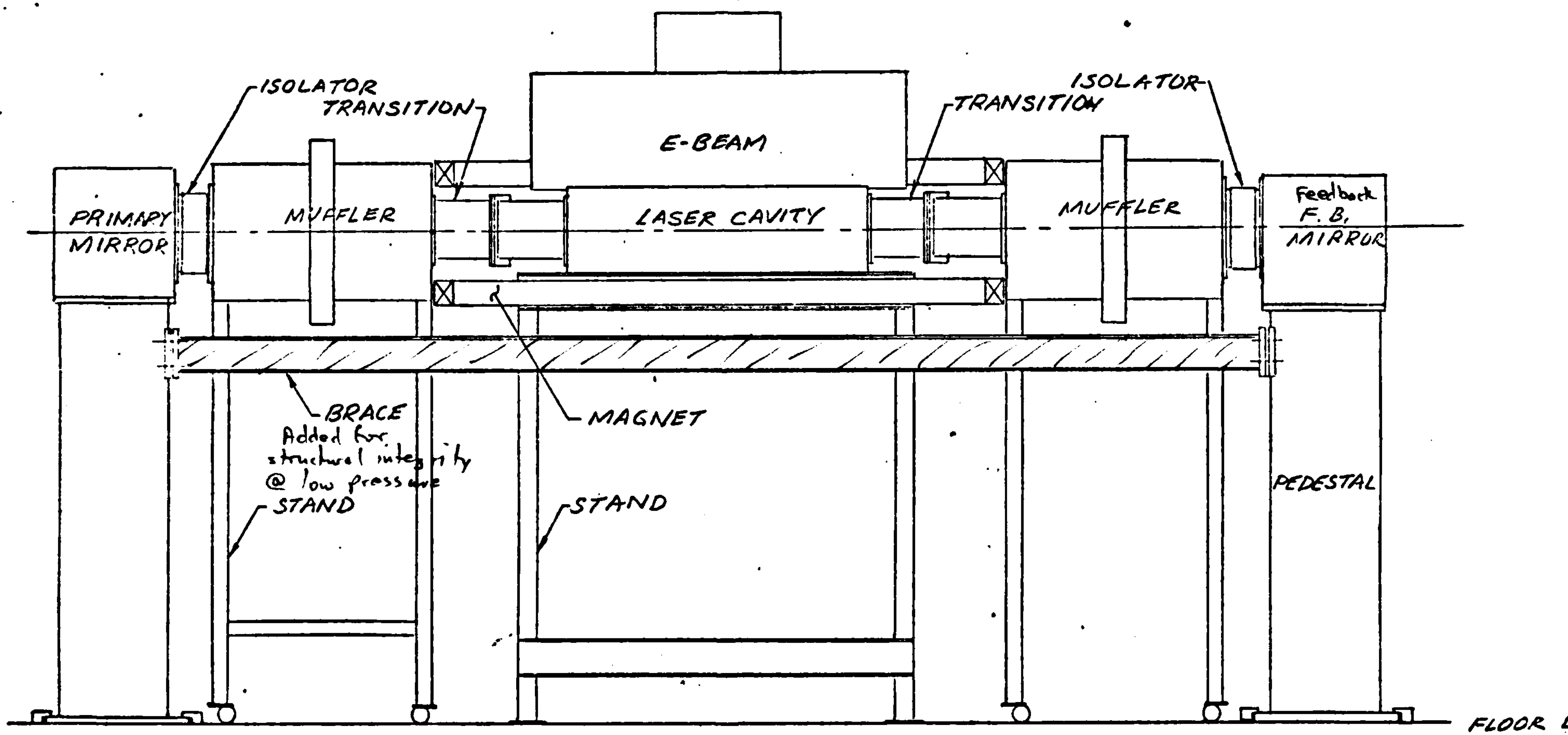
IR&D Task - Foil Testing

simulates both stress & thermal environments

Goal of 2.5×10^4 pulses @ $\overset{25}{60}$ Hz

(1000 sec @ 25 Hz)

PULSED CHEMICAL LASER
OPTICS TRAIN
SIDE ELEVATION



SPECIAL PERFORMANCE DIAGNOSTICS

Vu

- F_2 (NF_3) DISSOCIATION LEVEL
- LASER SPECTRA < Time integrated / Time Resolved
- TIME DEPENDENT GAIN.

F_2 (NF_3) DISSOCIATION LEVEL

OBJECTIVE: RELATE E-BEAM INITIATION CHARACTERISTICS AND GAS COMPOSITION TO F-ATOM FORMATION. $\boxed{(\{F\}/\{F_2\} \sim 5 \times 10^{-3})}$

0.2 → 0.5%

MOTIVATION:

- COUPLE LASER CODE TO EXPERIMENTS.
- DEVELOP SCALING RELATIONS.

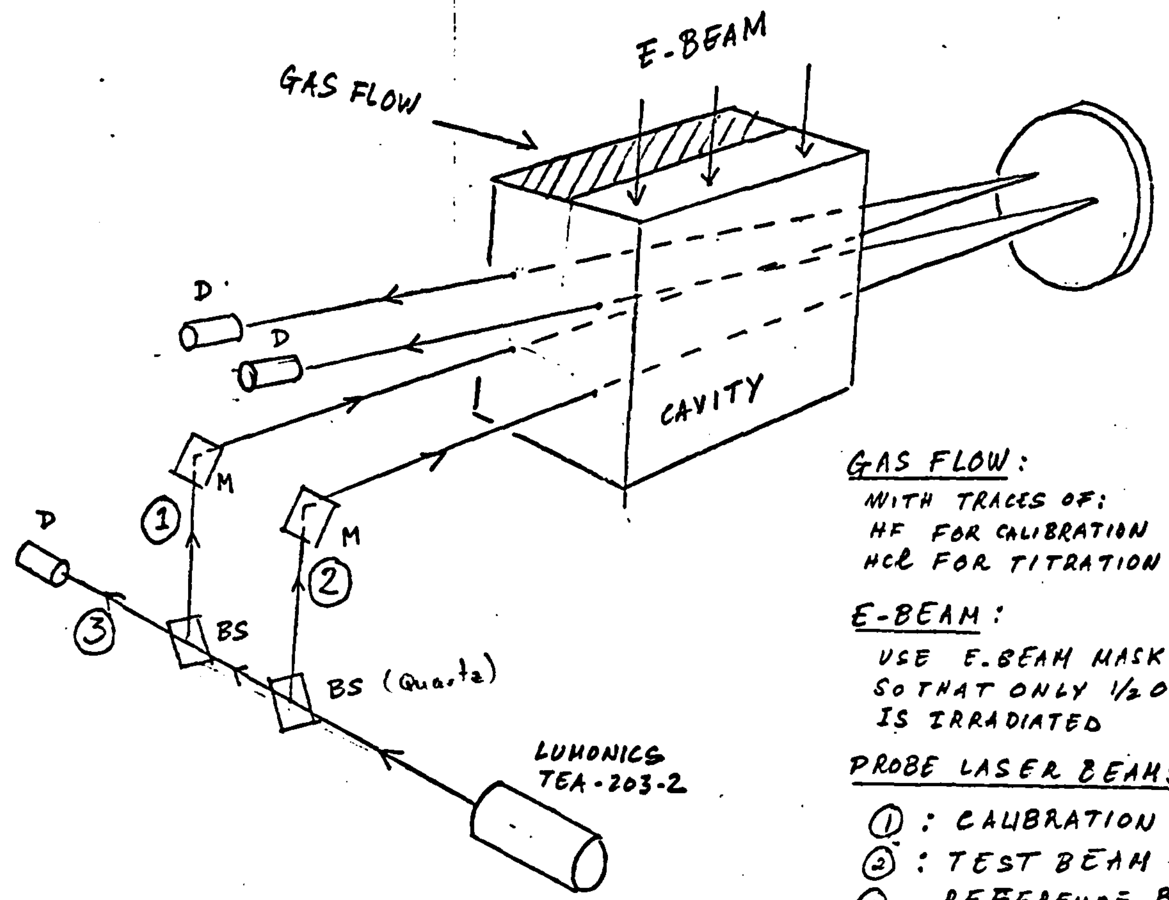
APPROACH: USE SINGLE LINE ($v = 1 \rightarrow 0$) PULSED HF PROBE LASER TO MEASURE PRODUCT CONCENTRATION IN TITRATION REACTION:

$$F + HCl \rightarrow \underline{HF} + Cl$$

TASKS:

- SELECT HF PROBE LASER (LUMONICS TEA 203).
- SELECT DETECTORS (MOLECTRON PYROELECTRIC P3-01).
- IMPLEMENT HF CLEAN-UP OF F_2 SUPPLY. (NaF scrubber)
- IMPLEMENT HCl INJECTION SYSTEM.
- IMPLEMENT HF CALIBRATION GAS FLOW SYSTEMS.
- IMPLEMENT DIAGNOSTIC OPTICS.
- TEST.

SCHEMATIC FOR F-ATOM MEASUREMENT



GAS FLOW:
WITH TRACES OF:
HF FOR CALIBRATION
HCl FOR TITRATION

E-BEAM:
USE E-BEAM MASK
SO THAT ONLY 1/2 OF CAVITY
IS IRRADIATED

PROBE LASER BEAMS

1 : CALIBRATION BEAM
2 : TEST BEAM
3 : REFERENCE BEAM

NOMENCLATURE

D: PYROELECTRIC DETECTOR
M: MIRROR
BS: QUARTZ BEAM SPLITTER

F_2 (NF_3) DISSOCIATION MEASUREMENT:

DESIGN CONSIDERATIONS

ABSORPTION LINE

- USE HF 1P8 LINE (2,783μ) INSTEAD OF 1P4 LINE.
- TOTAL CAVITY LENGTH CAN BE USED AS ABSORPTION PATH.

If 1P4 line is used ~2cm will absorb 90% of rad
1P8 is 100 times less sensitive.

PROBE LASER

- LUMONICS TEA-203, SINGLE LINE OPERATION

  $I \leq 50 kW/cm^2$, $\tau = 0.5\mu s$
- TEST AND CALIBRATION BEAM INTENSITIES

  $I \ll I_S$: AVOID HF BLEACHING

  I: BEAM INTENSITY $\approx 0.1 kW/cm^2$

  I_S: SATURATION INTENSITY $\approx 1.7 kW/cm^2$

DETECTORS

- PYROELECTRIC (MOLECTRON P3-01, $\tau_R = 50 ns$,

  $V/I = 3 mV/(kW/cm^2)$)
- FILTERS AND FOCUSSING LENSES ON DETECTORS.

CALIBRATION

- INTRA-CAVITY CALIBRATION
- CALIBRATION MEASUREMENT SIMULTANEOUS WITH DISSOCIATION MEASUREMENT

LASER SPECTRAL MEASUREMENT

OBJECTIVE:

RELATE DF AND CO_2 TIME-DEPENDENT AND TIME-INTEGRATED SPECTRA TO CAVITY AND INITIATION CONDITIONS.

MOTIVATION:

- ADDRESS MODE FORMATION
- TAILOR SPECTRA TO REMOVE LONG WAVELENGTHS ($\geq 4.1\ \mu m$)
- PROVIDE DATA BASE FOR MODELING AND SCALING

APPROACH:

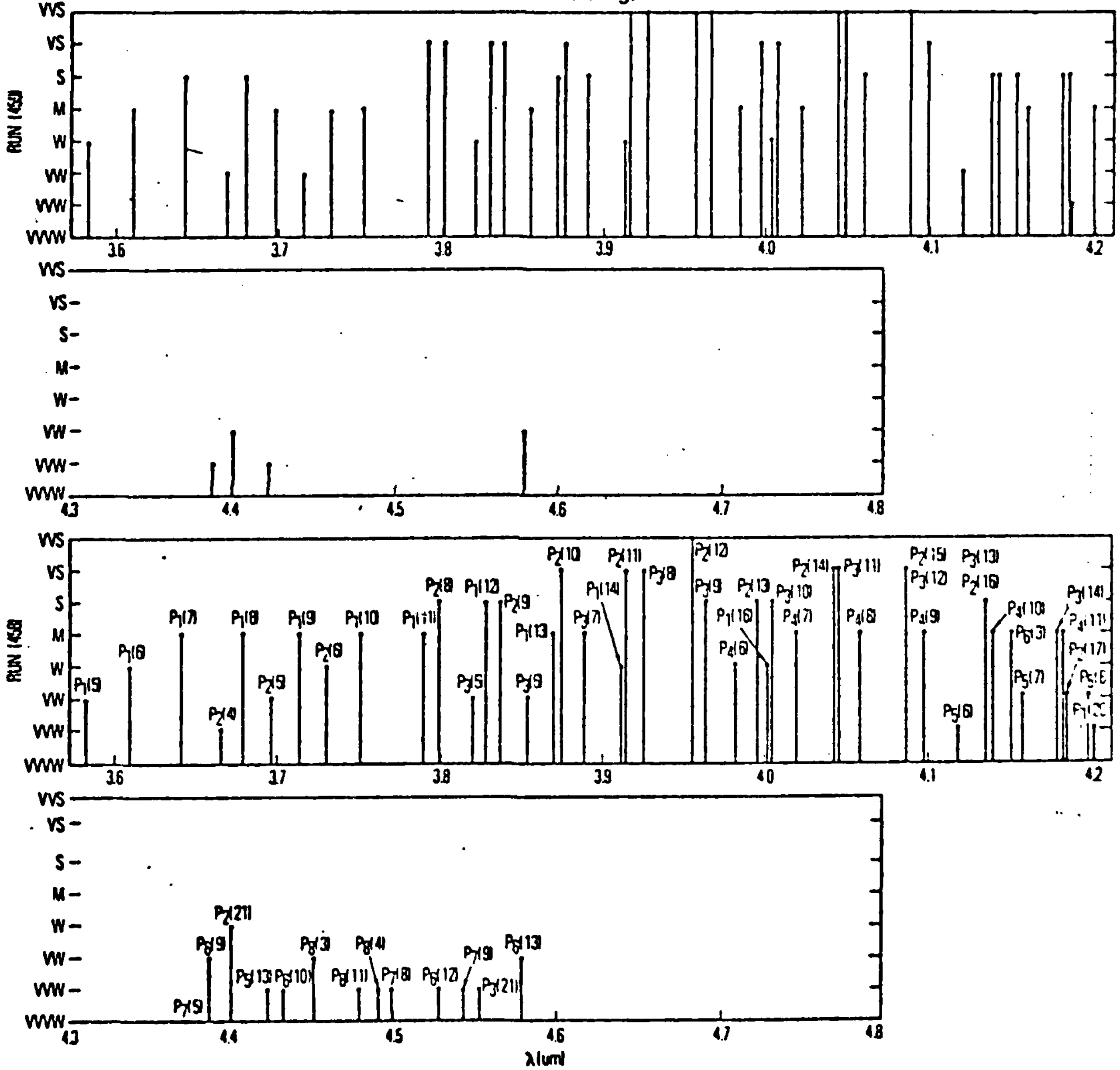
- GRATING SPECTROMETRY USING EBERT-FASTIE CONFIGURATION
- IR PHOTOGRAPHY FOR TIME-INTEGRATED SPECTRA
- PYROELECTRIC DETECTORS FOR TIME-RESOLVED SPECTRA; DIGITAL DATA ACQUISITION
  Have capability to look @ 10 lines simultaneously

TASKS:

- IMPLEMENT SPECTROMETER OPTICS
- SELECT AND CALIBRATE GRATINGS
- IMPLEMENT IR CAMERA
- IMPLEMENT DETECTOR ARRAYS (10)
- IMPLEMENT DATA ACQUISITION
- TIME-INTEGRATED MEASUREMENT
- TIME RESOLVED MEASUREMENT

DF SPECTRA

RUNS 459/458 (NF_3)

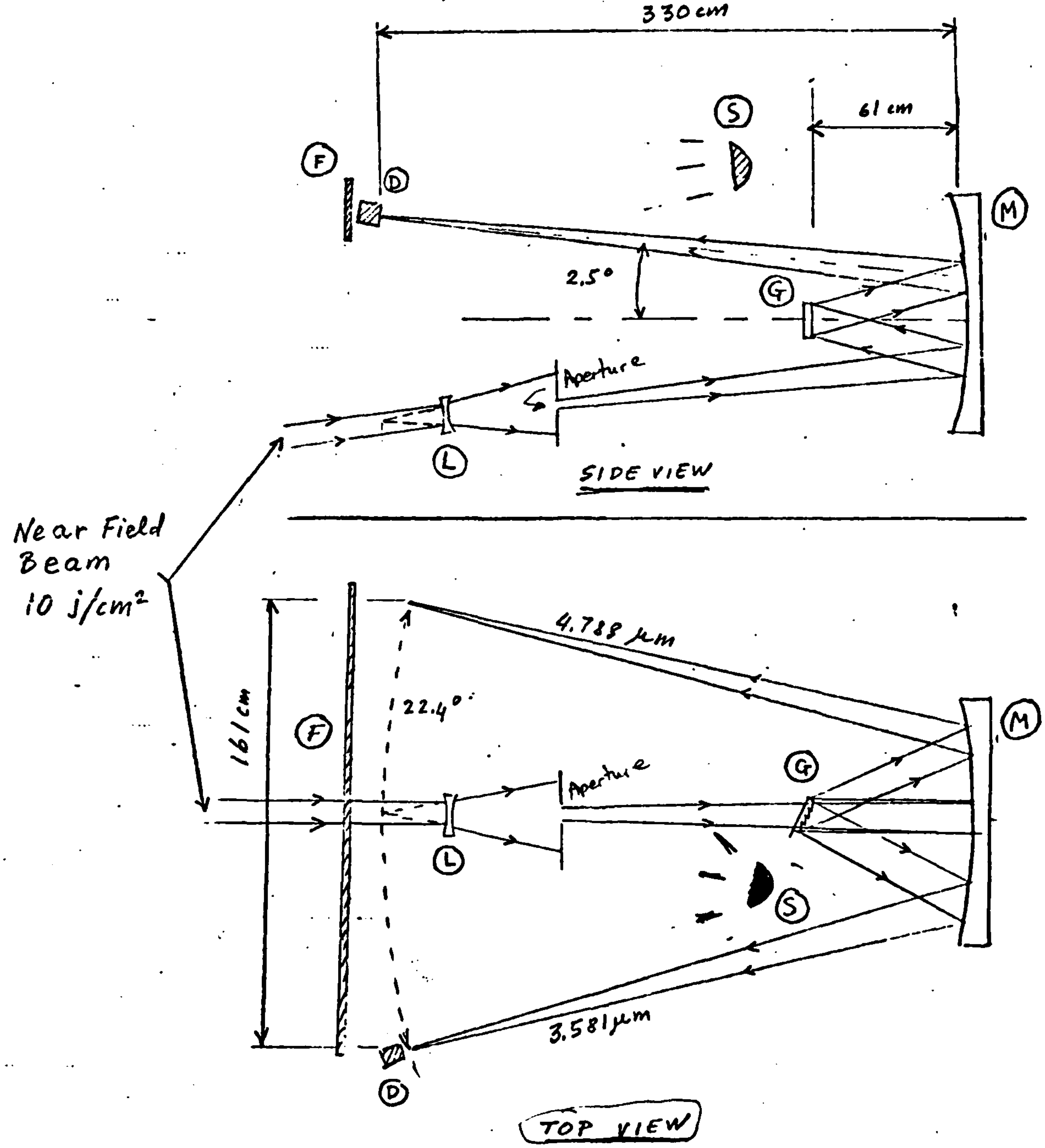


$35 F_2 : 18 D_2 : 35 NF_3 : 12 O_2$

\# 458 200 torr

\# 459 400 torr

SPECTROMETER



Ⓛ: Diverging Lense, CaF_2, $f = -10$ cm

Ⓜ: Spherical Mirror, $f = 330$ cm

Ⓖ: Blazed Grating, (5×5 cm) 300 ℓ/mm for DF Spectra 150 ℓ/mm for DF/CO_2 Spectra

Ⓓ Pyroelectric Detector Molectron P1-61 (1 of 10 shown)

Ⓕ: Film Plane, 35mm Kodak 5367.No.1

Ⓢ: Stobos cope Flach Gen Rad 1531AB

SPECTRAL MEASUREMENT: DESIGN CONSIDERATIONS

DF SPECTRAL RANGE

- $\boxed{\text{69 LINES}}$ BETWEEN 3.581μM AND 4.788μM
- SMALLEST LINE SEPARATION: 0.003μM

Expect 40. Have 8 data channels available for tests.

GRATING SPECTROMETER

- EBERT-FASTIE CONFIGURATION
- MAXIMUM REVOLVING POWER: 0.00026μM
- LINE SEPARATION CAPABILITY:

$$\Delta S/\Delta\lambda = 1.3\text{CM}/0.01\mu\text{M}$$

- TOLERANCE TO INCIDENT BEAM JITTER:

$$\Delta\theta_I = \leq \pm 2.5\text{M RAD}$$

- N_2 FLUSH TO AVOID ABSORPTION BY CO_2.

TIME-INTEGRATED MEASUREMENT: IR PHOTOGRAPHY

- PRINCIPLE: HEATING OF FILM BY LASER LINES CHANGES FILM SENSITIVITY.
- LINEAR RESPONSE FOR $J \leq 500$ mJ/CM^2 (SILVER HALIDE EMULSION).
- QUANTITATIVE MEASUREMENT FOR ALL LASING LINES.

TIME-RESOLVED MEASUREMENT: PYROELECTRIC DETECTORS

- 10 STRONGEST LINES ($3.8\mu M < \lambda < 4.2\mu M$) MEASURED BY MOLECTRON P1-61 PYROELECTRIC DETECTORS.
- WORKING INTENSITY RANGE $0.04\text{kW/MM}^2 < I < 4\text{kW/MM}^2$
- DIGITAL DATA ACQUISITION

TIME DEPENDENT GAIN

OBJECTIVE:

MEASURE LASER GAIN AT SELECTED WAVELENGTHS

MOTIVATION:

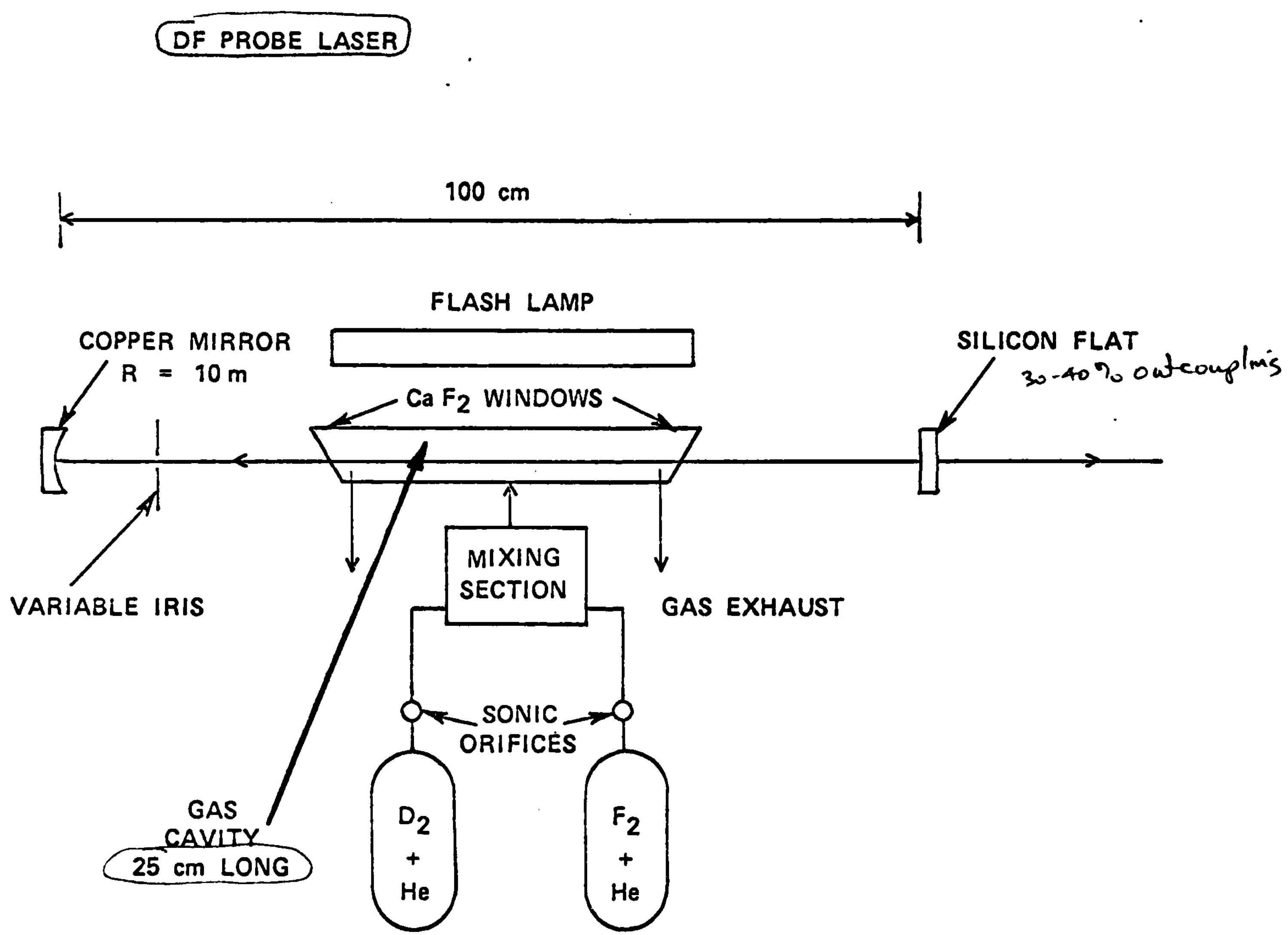
PROVIDE DATA BASE FOR SYSTEM DESIGN, MODELING AND SCALING

APPROACH:

- FABRICATE PROBE DF LASER WITH 4 μSEC PULSE TO MEASURE TIME-RESOLVED GAIN
- LINE SELECTION BY 300 ℓ/MM GRATING

TASKS:

- FABRICATE FLASHLAMP INITIATED DF PROBE LASER
- IMPLEMENT OPTICS AND DETECTOR ARRAY
- GAIN MEASUREMENT


DF PROBE LASER
100 cm
FLASH LAMP
COPPER MIRROR
R = 10 m
Ca F_2 WINDOWS
SILICON FLAT
30-40% outcoupling
VARIABLE IRIS
MIXING SECTION
GAS EXHAUST
SONIC ORIFICES
GAS CAVITY
25 cm LONG
D_2 + He
F_2 + He

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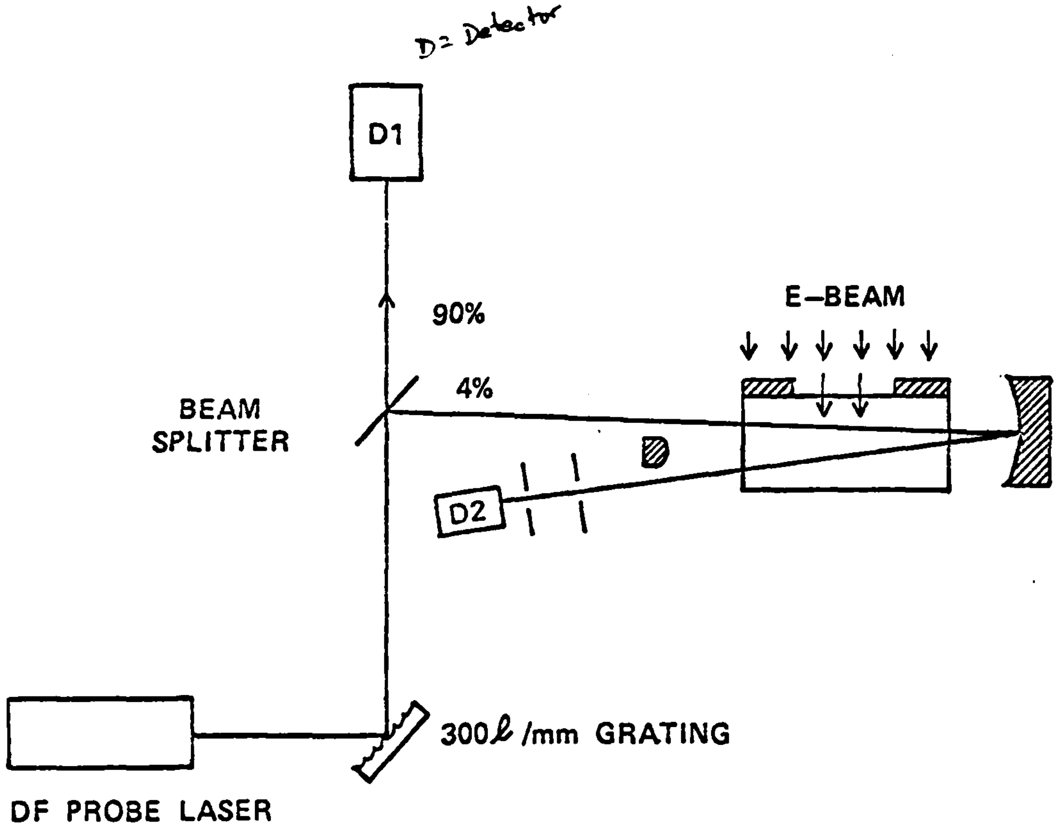
SCHEMATIC FOR TIME RESOLVED GAIN MEASUREMENT



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TIME DEPENDENT GAIN: DESIGN CONSIDERATIONS

DF PROBE LASER

- FLASHLAMP INITIATED
- LASER PULSE:

  $\tau = 4\ \mu s$ (FWHM)

  $I \approx 200\ W/cm^2$ PER LINE
- GAIN MEASUREMENT: ± 15% UNCERTAINTY WITH 100 CM LONG OPTICAL CAVITY OF PROBE LASER

EXPERIMENTAL CONDITIONS

- TEST BEAM INTENSITY:

  $$I_T << I_S$$

  I_T : TEST BEAM INTENSITY (10 W/cm^2)

  I_S : SATURATION INTENSITY (600 kW/cm^2)
- LENGTH OF E-BEAM APERTURE:

  REDUCED TO 25 CM TO AVOID AMPLIFIED SPONTANEOUS EMISSION (ASE)

SPECIAL PERFORMANCE DIAGNOSTICS: STATUS

F_2 (NF_3) DISSOCIATION MEASUREMENT

- DIAGNOSTIC SYSTEM READY FOR SHAKEDOWN AND TESTING.

SPECTRAL MEASUREMENT

- ASSEMBLY IN PROGRESS
- TIME INTEGRATED MEASUREMENT:
  - SPECTROMETER READY FOR TESTING 3/26/84.
- TIME RESOLVED MEASUREMENT:
  - PYROELECTRIC DETECTORS DELIVERED 3/12/84.
  - INSTALL 1 DATA CHANNEL 3/19-3/26/84.
  - IMPLEMENT DETECTOR ARRAY AND DATA ACQUISITION SYSTEM 3/26-4/27/84.
  - READY FOR TESTING 4/30/84.

TIME DEPENDENT GAIN MEASUREMENT

- TEST OPTICS COMPLETED
- PROBE LASER READY FOR SHAKEDOWN AND TESTING.
- TESTING 5/7/84 (TENTATIVE).

DATA ACQUISITION REQUIREMENTS

Nelson Orozco

- EXPERIMENTS TO BE DONE

	Oscillo-SCOPE	* DATA PRECISION	** LeCROY
CHANNELS AVAILABLE	(4)	(4)	(8)
: F-ATOM FORMATION			
GUN CURRENT		1	
GUN VOLTAGE	1		
PROBE LASER PULSE SHAPE		1	
ABSORPTION REF. PATH		1	
ABSORPTION TEST PATH		1	
CAVITY PULSE OVERPRESSURE	1		
: TIME RESOLVED LASER SPECTRA			
GUN CURRENT		1	
GUN VOLTAGE		1	
CAVITY PULSE OVERPRESSURE		1	
LASER PULSE SHAPE		1	
SPECTRA MEASUREMENTS			8

* Each unit has 2 channels. Only one in house now. Other on order

** Lecroy Inst. will be ordered this week

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DATA ACQUISITION REQUIREMENTS

	SCOPE (4)	DATA PRECISION (4)	LeCROY (8)
: TIME RESOLVED LASER GAIN MEASUREMENTS			
GUN CURRENT		1	
GUN VOLTAGE		1	
CAVITY PULSE OVERPRESSURE		1	
LASER PULSE SHAPE		1	
GAIN MEASUREMENTS			2

DATA ACQUISITION REQUIREMENTS

- TIMING & SAMPLING

  PULSE WIDTH - 0.5 μs - 5 μs

  RESOLUTION - 50 ns

  PULSE SAMPLING RATE - > 20 MHz

  PULSE REPETITION RATE - 10 Hz → 30 Hz

  No. PULSE EVENTS - 18 MAX.

- No. CHANNELS - 12

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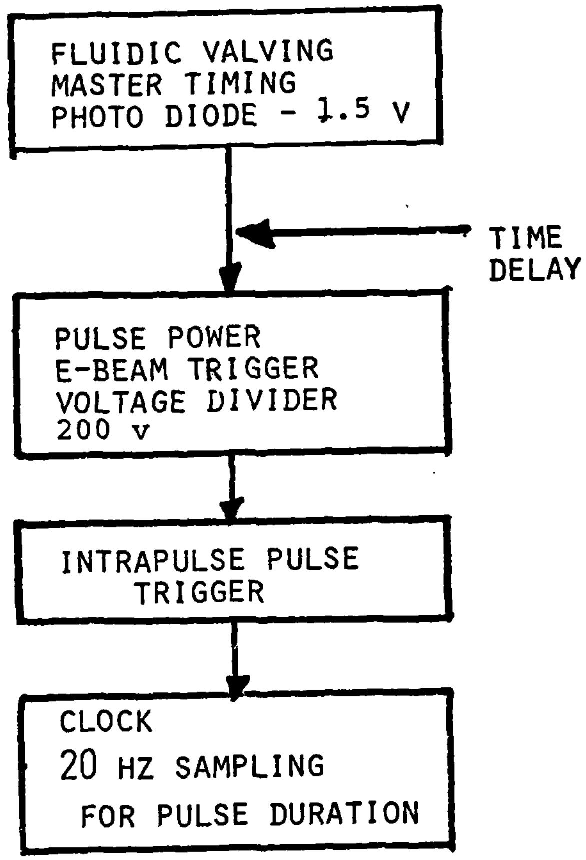
DATA ACQUISITION REQUIREMENTS

- TIMING & CONTROL LOGIC



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DATA ACQUISITION REQUIREMENTS

- SYSTEM HARDWARE REQUIREMENTS FOR SINGLE PULSE

  2 - DATA PRECISION DATA 6000 WAVEFORM ANALYZER (1 IN HOUSE)

  2 - DATA PRECISION MODEL 620 , 100 MHZ DIGITIZING MODULE 8 BIT RESOLUTION, 2 CHANNELS

  4 - DATA PRECISION MODEL 694-B PROBES

  2 - DATA PRECISION FIRMWARE 682-30 RS232C INTERFACE AND IEEE-4888 GPIB INTERFACE

  1 - LECROY 3500SA32 MULTICHANNEL ANALYZER

  2 - LECROY NIM MODEL 612AM 6-CHANNEL PHOTOMULTIPLIER AMPLIFIER

  6 - LECROY MODEL TR8837F 32 MEGASAMPLE/SEC. TRANSIENT RECORDER

  6 - LECROY MODEL 4501A NIM TO CAMAC ADAPTERS

  1 - LECROY MODEL 1434 CAMAC CRATE

  1 - LECROY MODEL 3501 CRATE CONTROLLER

  1 - LECROY 3500-38-488 INTERFACE

Components either in-house or 4-week delivery.

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DATA ACQUISITION REQUIREMENTS

- SYSTEM HARDWARE REQUIREMENTS FOR REP. PULSE

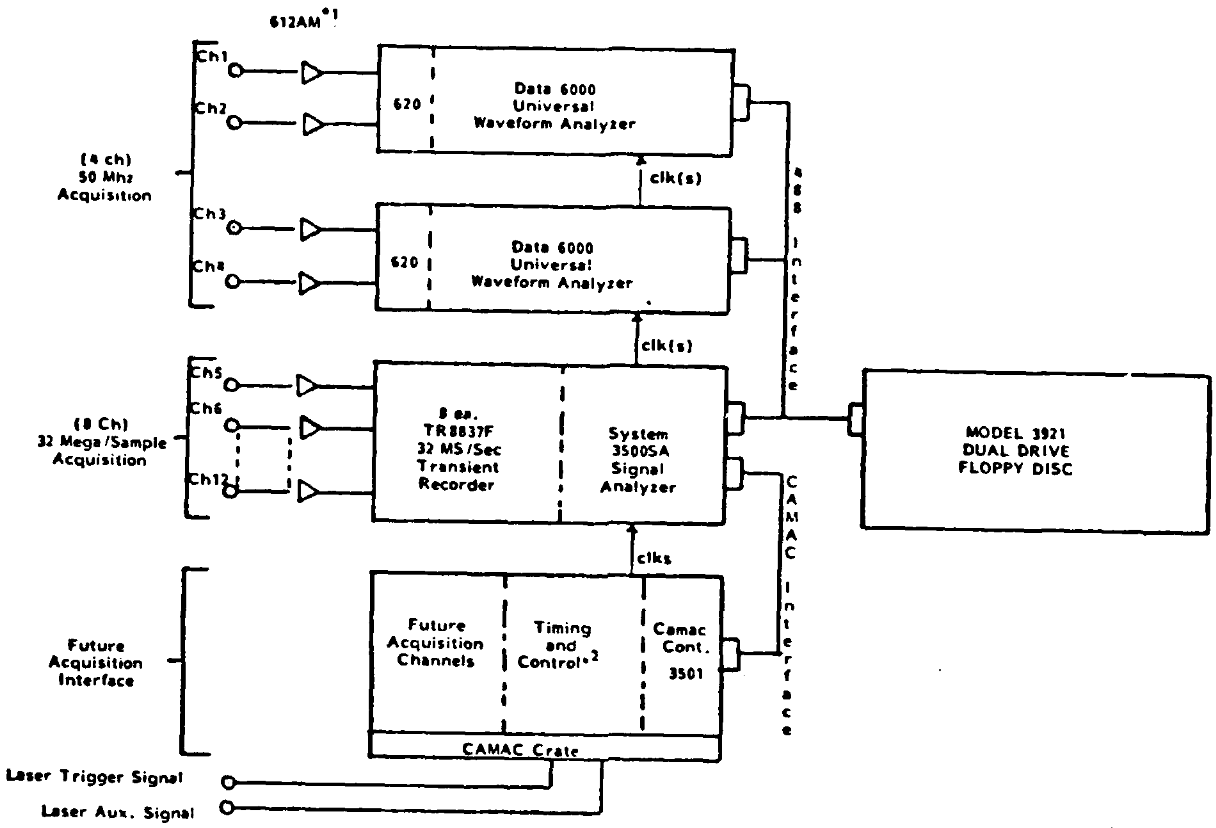
  SAME REQUIREMENTS FOR SINGLE PULSE

  1 - LeCroy NIM model 222/222N dual gate & delay generators

  1 - LeCroy NIM model 428F (430) quad linear fan in/fan out

  1 - LeCroy NIM model 620D 8-channel discriminator

  1 - LeCroy NIM model 688AL level adapter



NOTES:
*1 SW612AM NIM 6-Channel Photomultiplier Amplifier (2 ea) will be contained in CAMAC Crate using NIM to CAMAC adaptors.

*2 The Timing and Control Modules Include

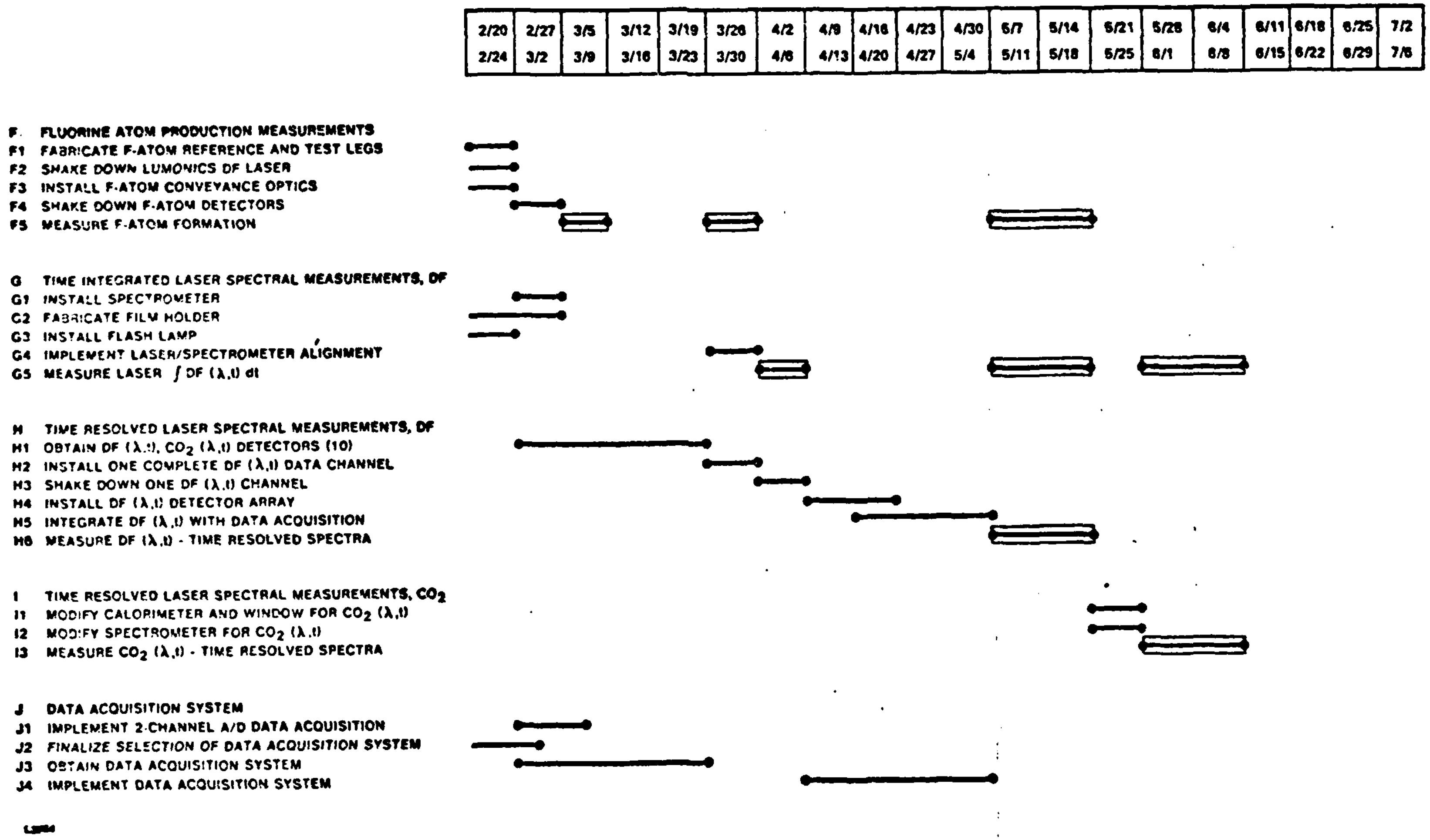
Lecroy 222 Dual Gate/Delay Generator
Lecroy 620D - 8 Channel Discriminator
Lecroy 428F - Quad Linear Fan In/Fan-Out
Lecroy 688AL - Level Adapter

L2875

Figure 2.8.5 Data Acquisition System Schematic

~1 week behind schedule. No catch-up capability. slips on 1/1 ratio

TABLE I: TEST PLAN: TASK III - SINGLE PULSE TESTING (Continued)



PULSED CHEMICAL LASER

PULSE POWER SYSTEM DESIGN

CHARLES PIKE

AVCO EVERETT

TECHNICAL APPROACH FOR REPETITIVE PULSE POWER SYSTEM

- REQUIREMENTS/SPECIFICATION
- IN-HOUSE AVAILABILITY OF SUBSYSTEMS
  - HV LOW CURRENT POWER SUPPLY
  - DOUBLE-ENDED CERAMIC THYRATRONS
  - OIL TANK
  - HV ENERGY STORAGE CAPACITORS
- DESIGN CONSIDERATIONS VS. TRADE-OFFS   Modified S^3 Device
- SIMPLE SKETCHES
- LAYOUT
  - SUBSYSTEM
  - COMPONENTS
  - INTERFACES

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ELECTRON GUN SPECIFICATIONS

- VOLTAGE 230 KV MAX.
- CURRENT DENSITY 11.3A/CM^2
- PULSE LENGTH 0.5 μSEC
- ENERGY 1640 J/PULSE
- AREA 1450 CM^2
- CURRENT 16.4KA
- PULSE RATE 30 HZ
- RESISTANCE 12.2 Ω (INITIAL)
- AV. ELCTRODE SPACING 4.3 CM
- CLOSURE VELOCITY 1.0 CM/μSEC
- RISE TIME 150 N SEC. MAX.

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REPETITIVE PULSE POWER SYSTEM: OPERATING PARAMETERS

• POWER SUPPLY	0-70 KV AT 50 MA DC
• PRIMARY STORAGE CAPACITY	390 MFD AT 40 KV
• THYRATRON CHARGING	STOP/START CHARGE
• INTERMEDIATE CAPACITY	1.0 MFD AT 80 KV
• INTERMEDIATE REGULATION	ZENOX UNITS
• INTERMEDIATE SWITCH	105 KV CERAMIC THYRATRON
• MODULATOR OUTPUT SWITCH	460 KV SPARK GAP (Identical to one in S^3)

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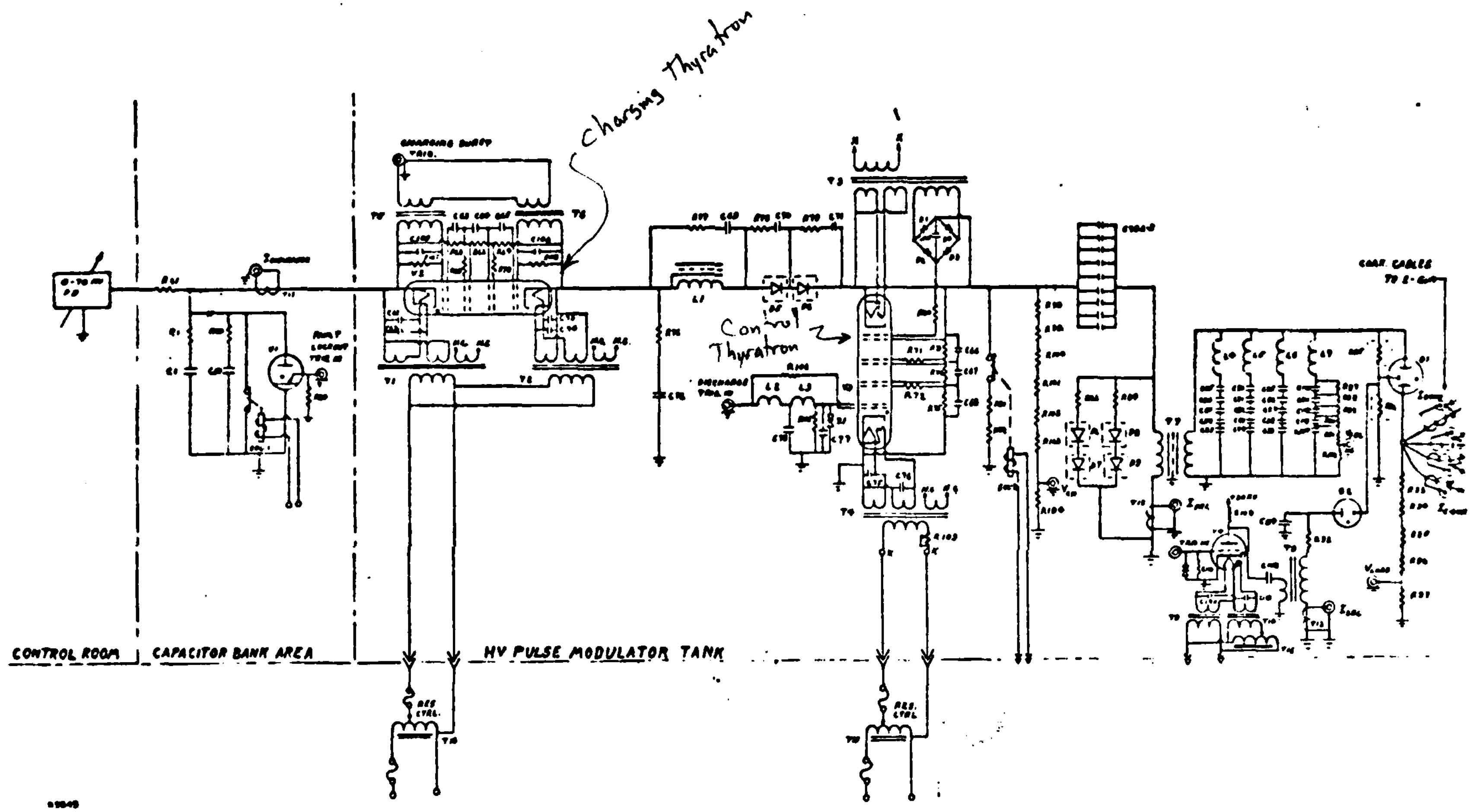

"Master Schematic of E-Gun HV Pulse Modulator System"

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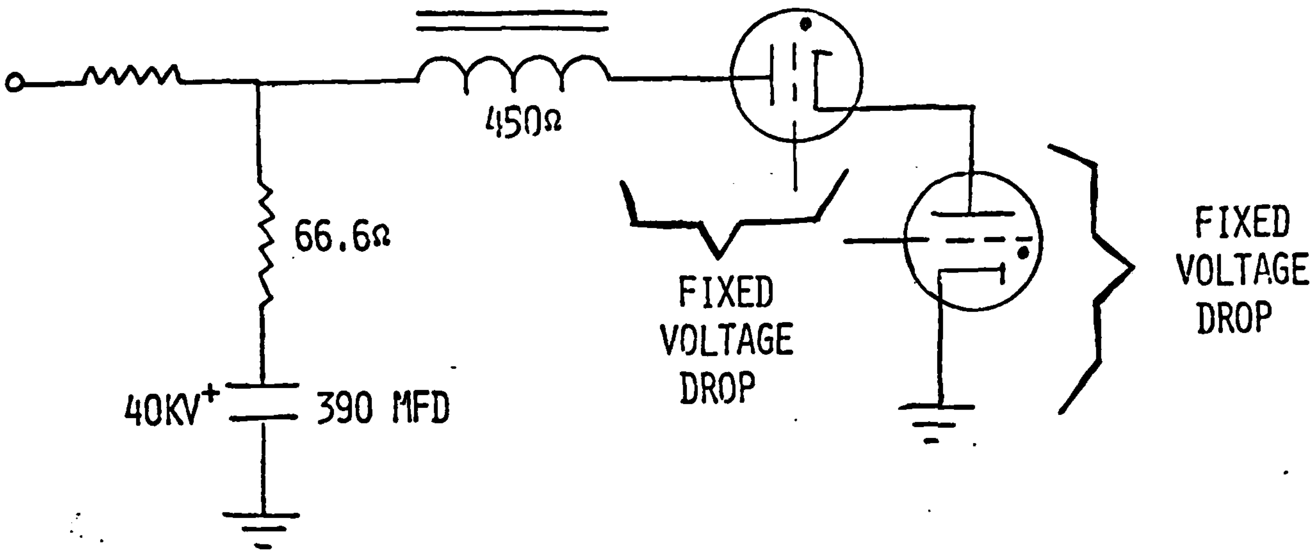
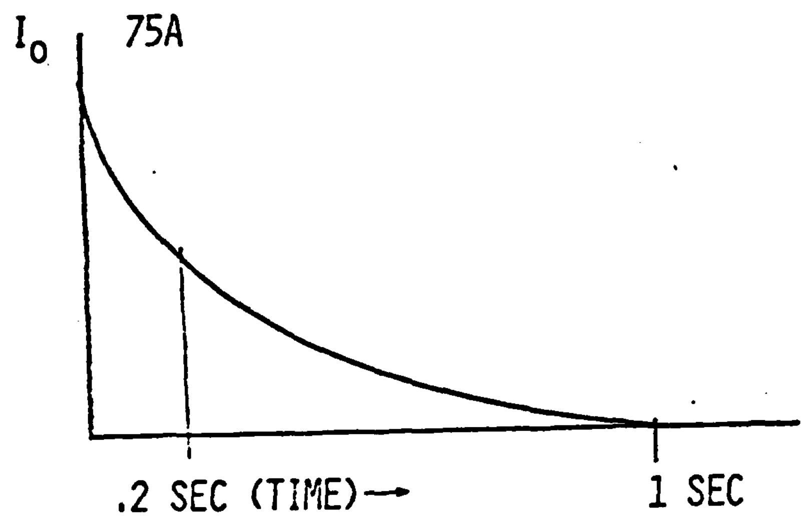
PEAK CAPACITOR BANK FAULT CURRENT





$$I_o = \frac{40\ KV - 2\ (TUBE\ DROP)}{66.6 + 450} = 75\ AMPS$$

$$RC = 390 \times 10^{-6} \times 516.6 = 0.2\ SEC$$

$$5RC = 1\ SEC$$

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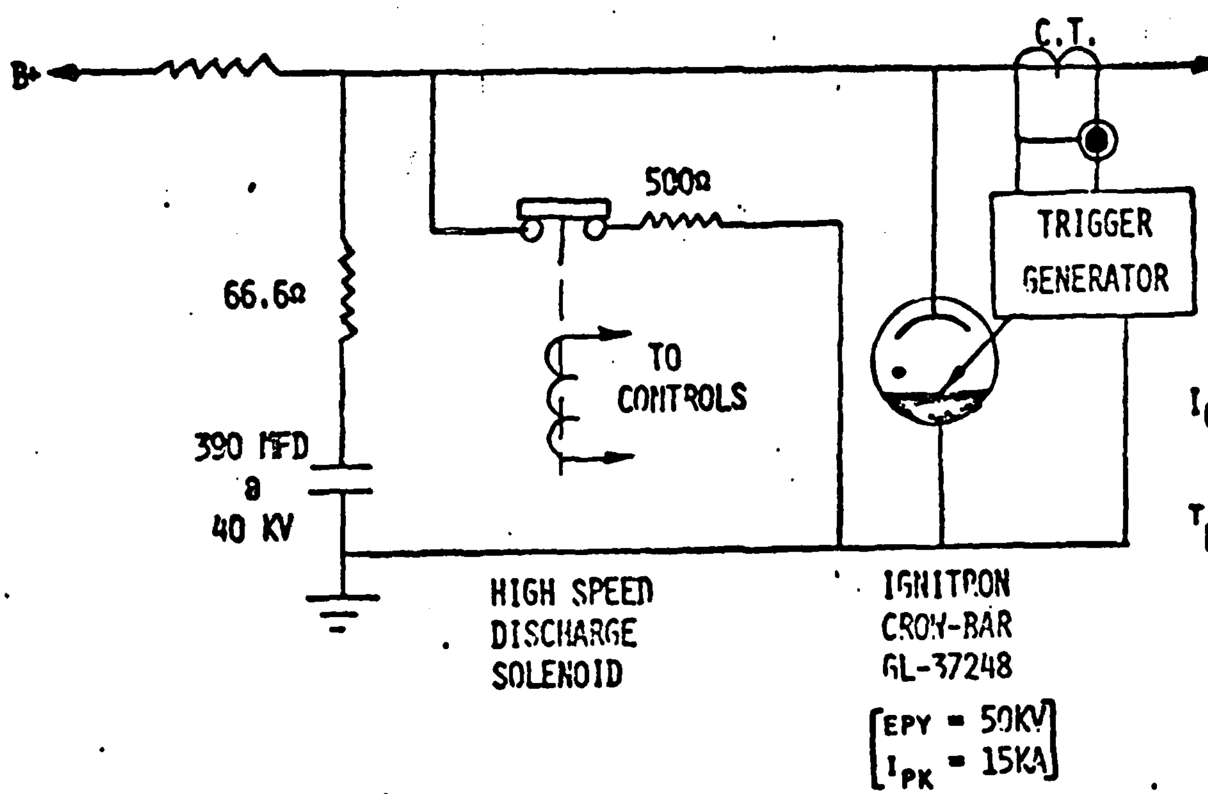
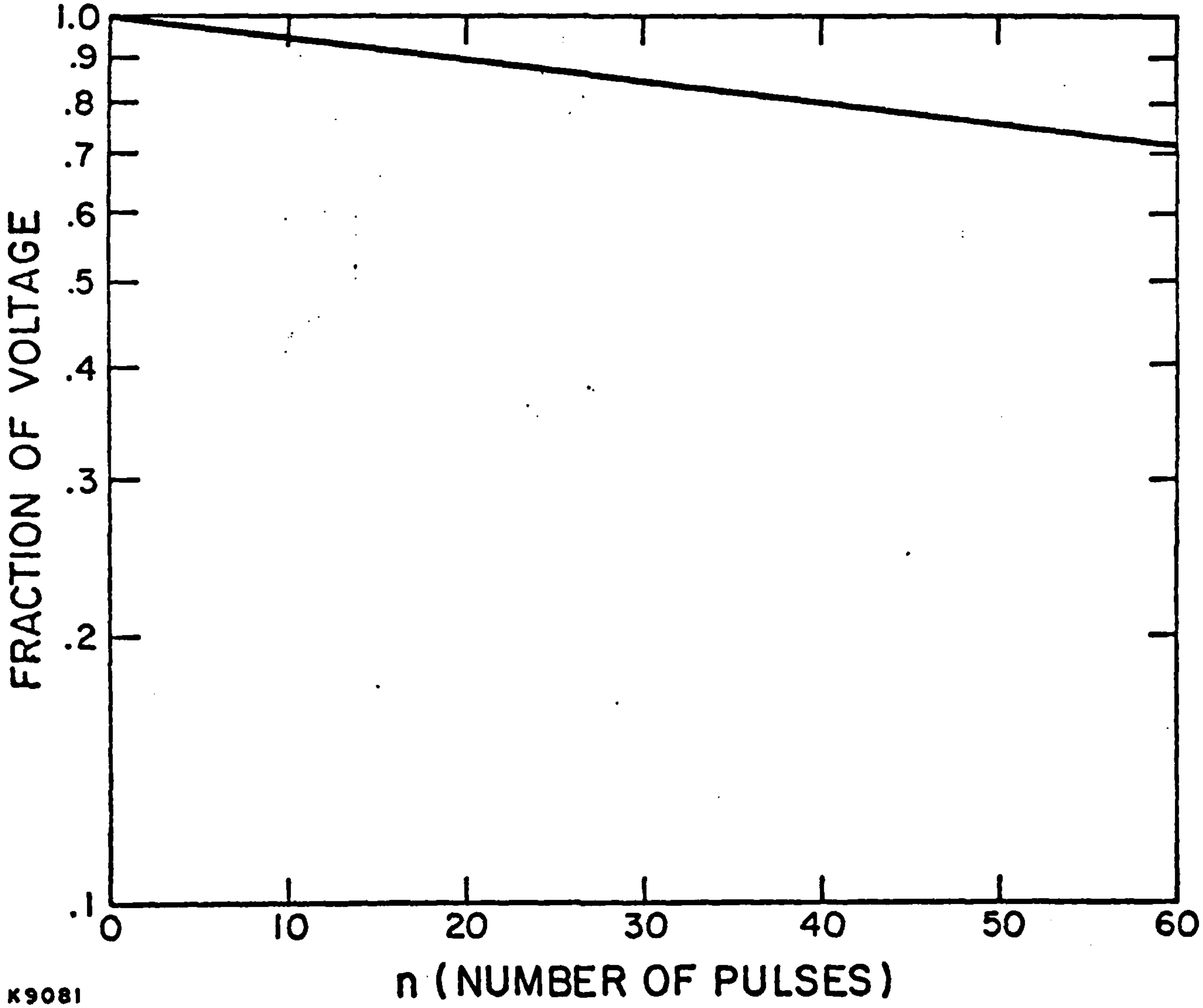
PROTECTIVE CROW-BAR DESIGN



$I_{CROW\text{-}BAR} = \frac{40KV}{66.6\Omega} = 601A$

$T_{FIRING} = <1\ \mu SEC$

AVCO EVERETT



K9081

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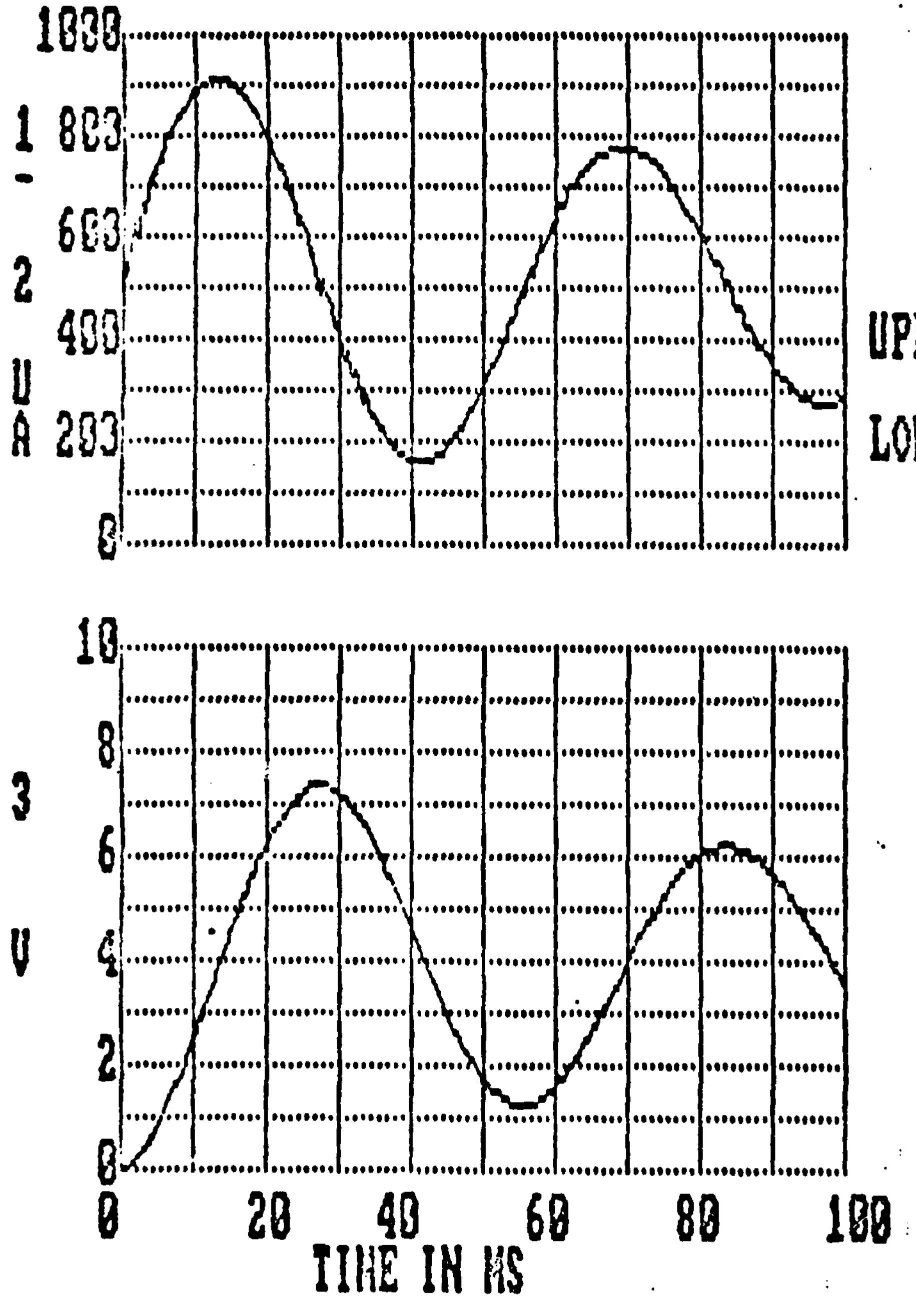
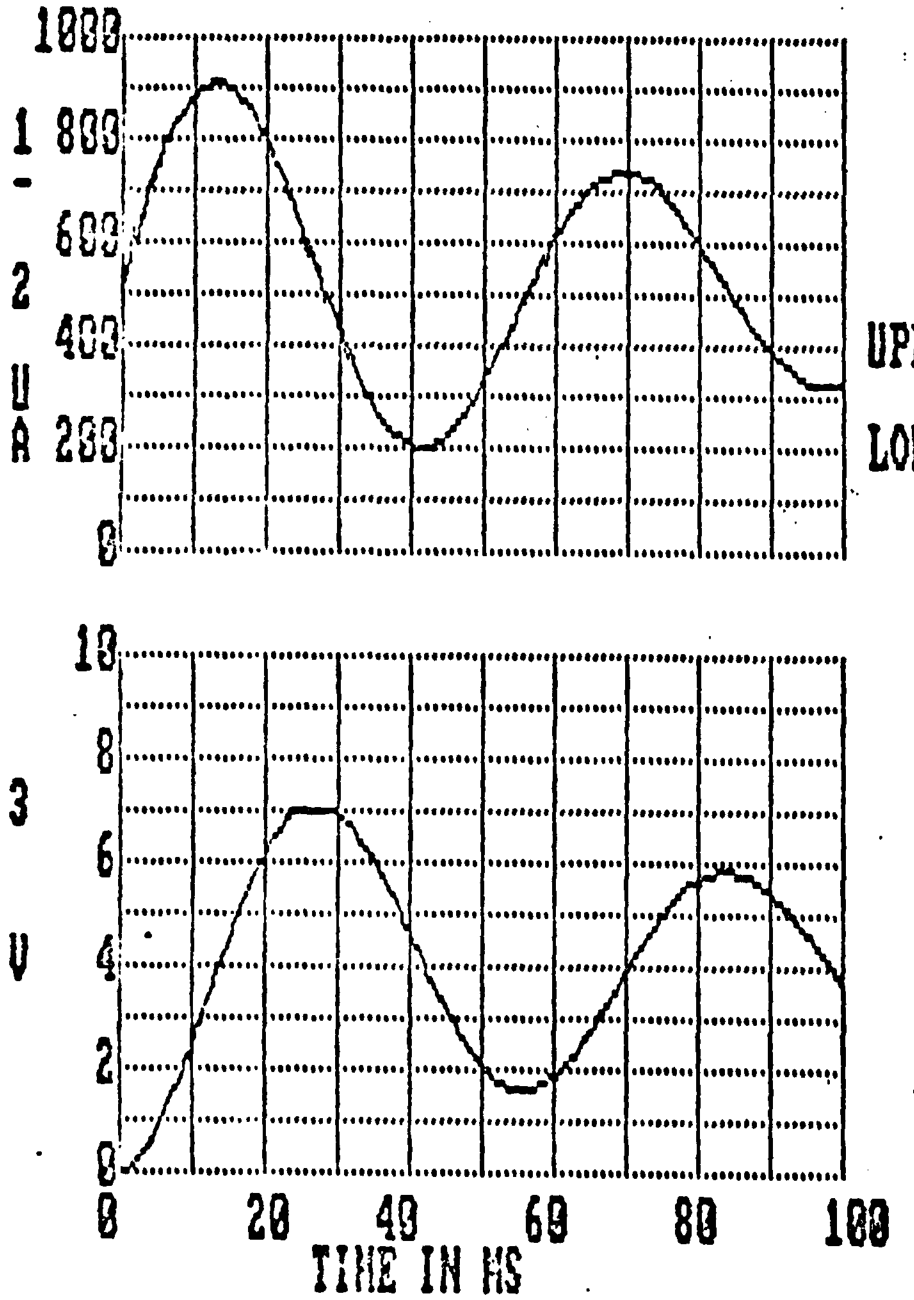


CHARGE1

	NODE	OFFSET	VALUE	TIME-MS
UPPER	1	.0005	-0.000	100.000
LOWER	3	0	3.525	100.000

NO DIODE

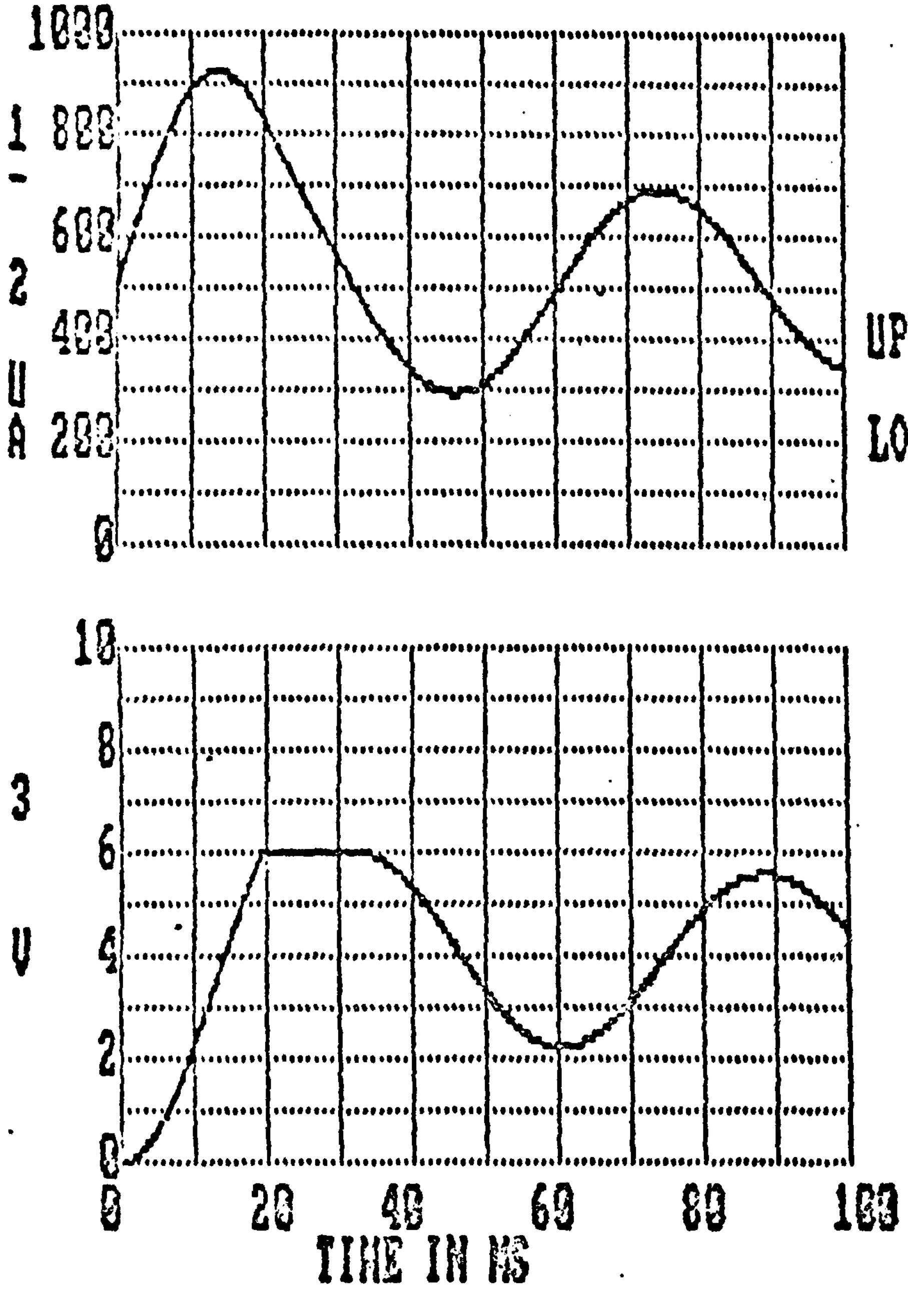
R = 400Ω



CHARGE1

	NODE	OFFSET	VALUE	TIME-MS
UPPER	1	.0005	-0.000	100.000
LOWER	3	0	3.742	100.000

7V ZENER



CHARGE1

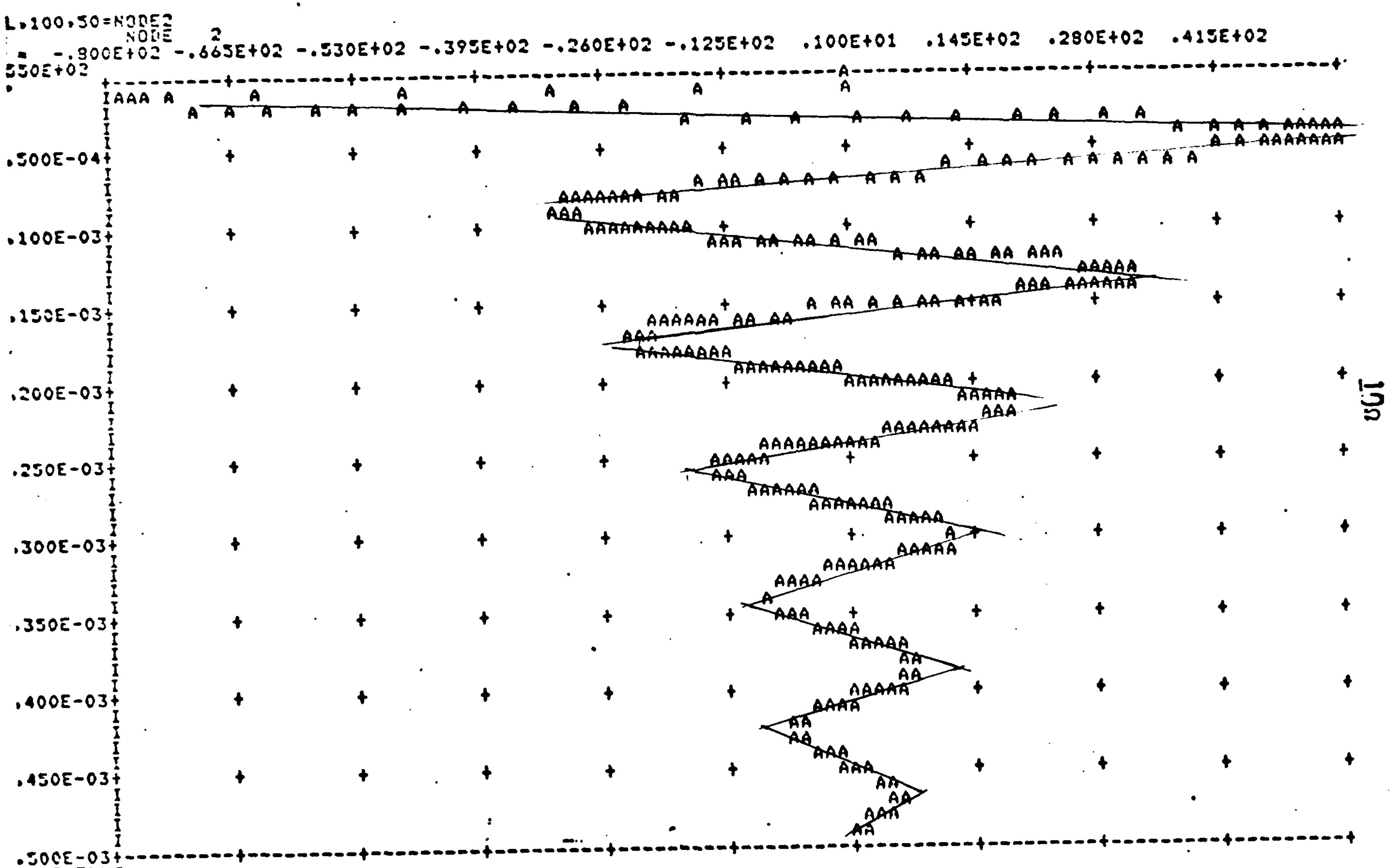
	NODE	OFFSET	VALUE	TIME-MS
UPPER	1	.0005	-0.009	100.000
LOWER	3	0	4.475	100.000

6V ZENER

COMPARISON OF THYRATRON BURST MODE OPERATION

	MARCONI BURST MODE	AVCO BURST MODE
DOUBLE-ENDED	CX1199B	CX1171B
CERAMIC THYRATRON	(3" DIA.)	(3" DIA.)
PULSED STORED ENERGY	6KJ	2.6 KJ, MAX.
PULSE LENGTH	30 μSEC	30 μSEC
PRF	67 PPS	30 PPS
PFN VOLTAGE	105 KV	80KV
PULSE DISCHARGE CURRENT	4800 $\hat{A}$	3200 $\hat{A}$
BURST ENERGY	400 KJ FOR 1 SEC	49.2 KJ FOR 1 SEC

AVCO EVERETT



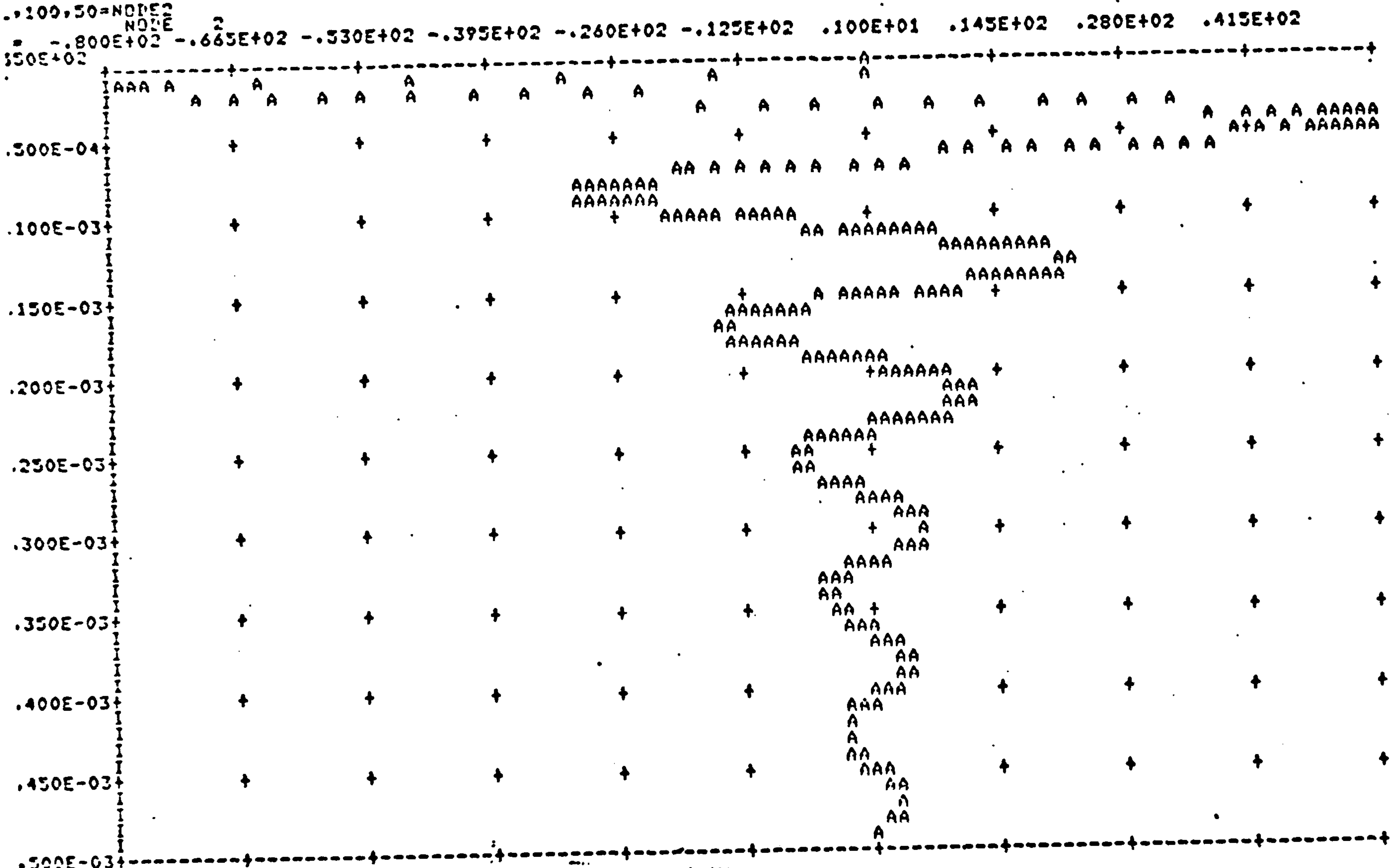
UN/OUTPUT

ESTART FILE? (Y/N)

RY.
O FI(4,0)5
CAP(D-DIODE)
SETUP PHASE

7a

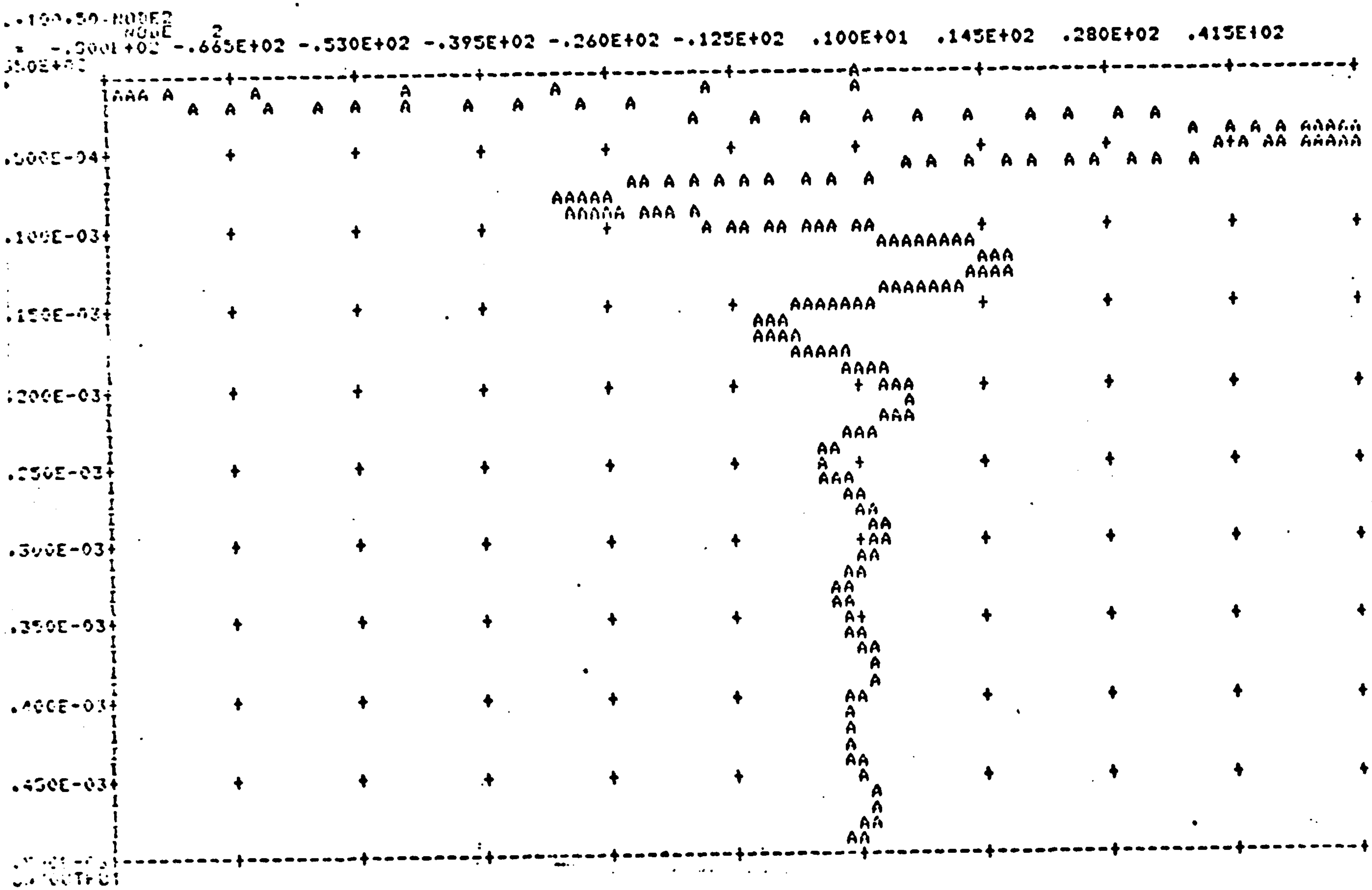
.100,50=NODE2



UN/OUTPUT

ESTART FILE? (Y/N)

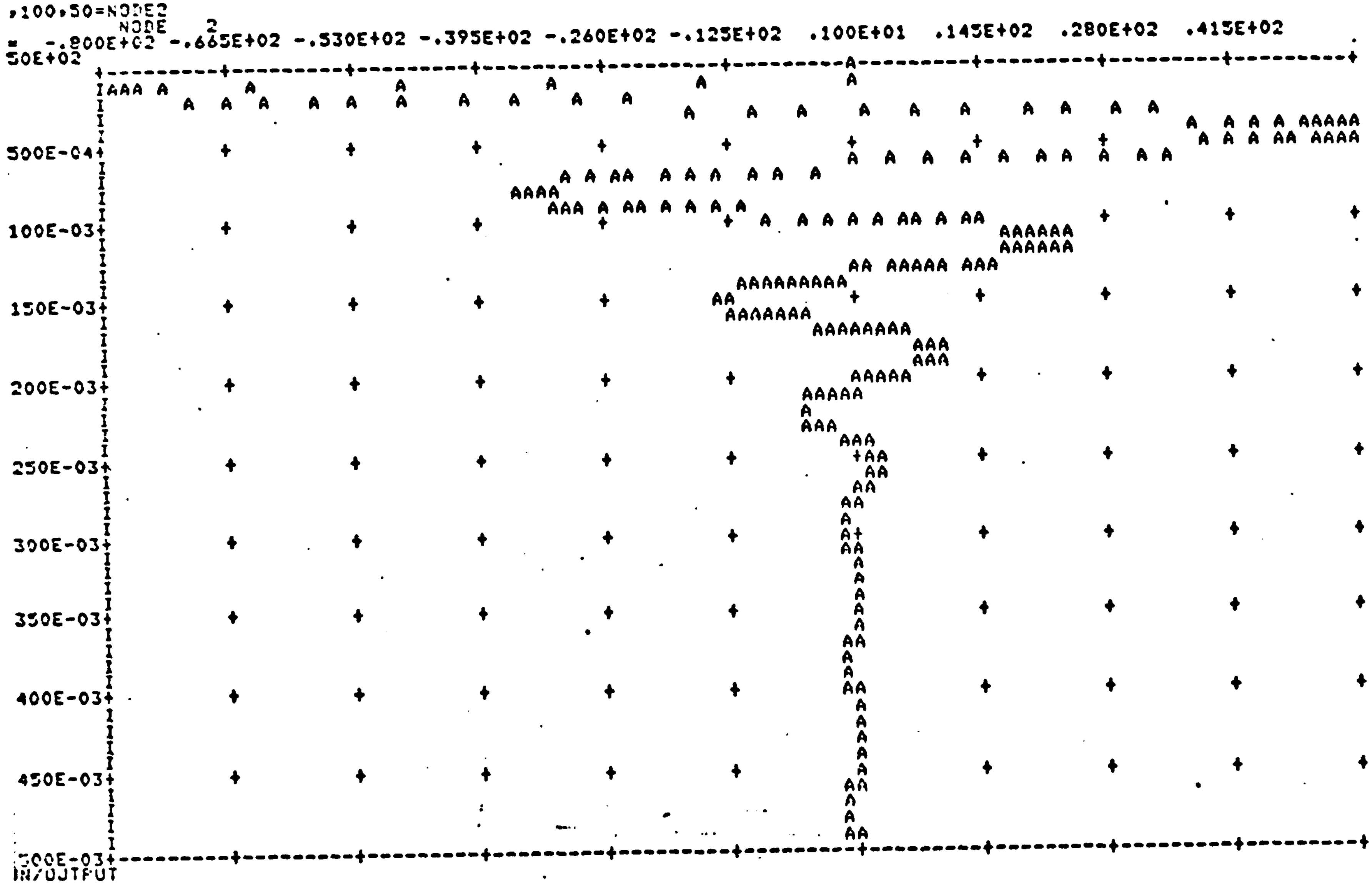
D/.
70 S:(4,0)10
ETAF(D-DIODE)
SETUP PHASE
11-36019



5Ω selected for use!

FILE? (Y/N)

,100,50=NODE2

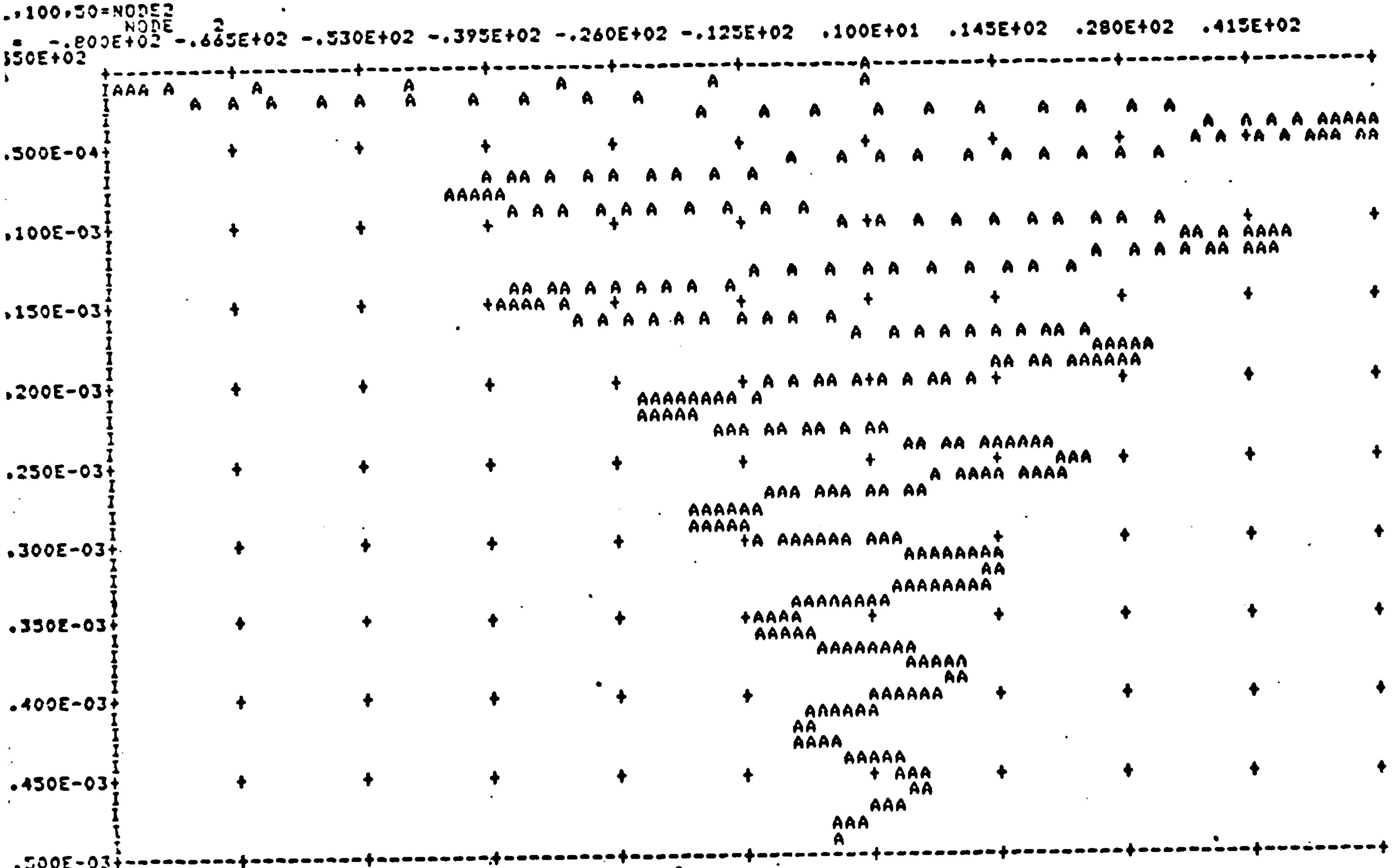


IN/OUTPUT

.START FILE? (Y/N)

LE NAME
?E
DIODE ALREADY EXISTS, USE ANOTHER NAME

.100,50=NODE2

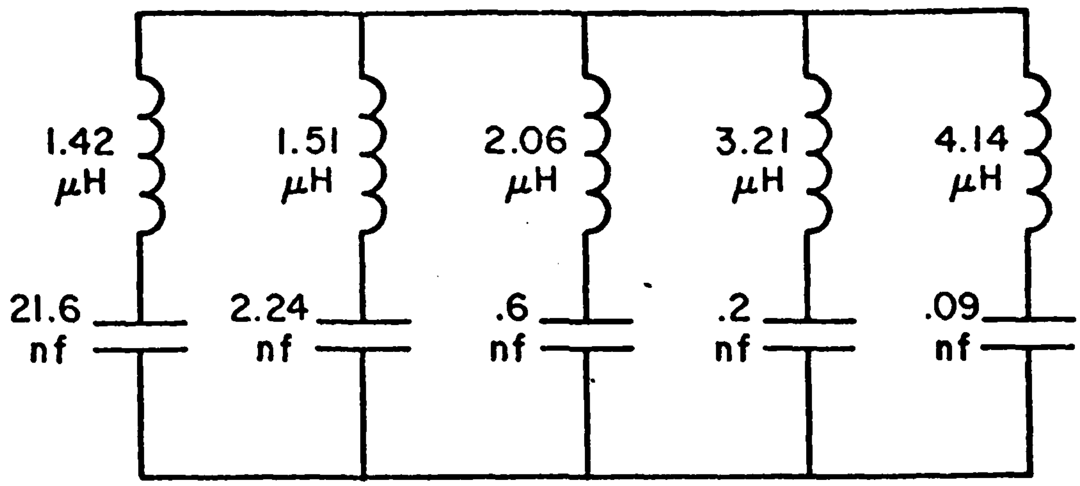


UN/OUTPUT

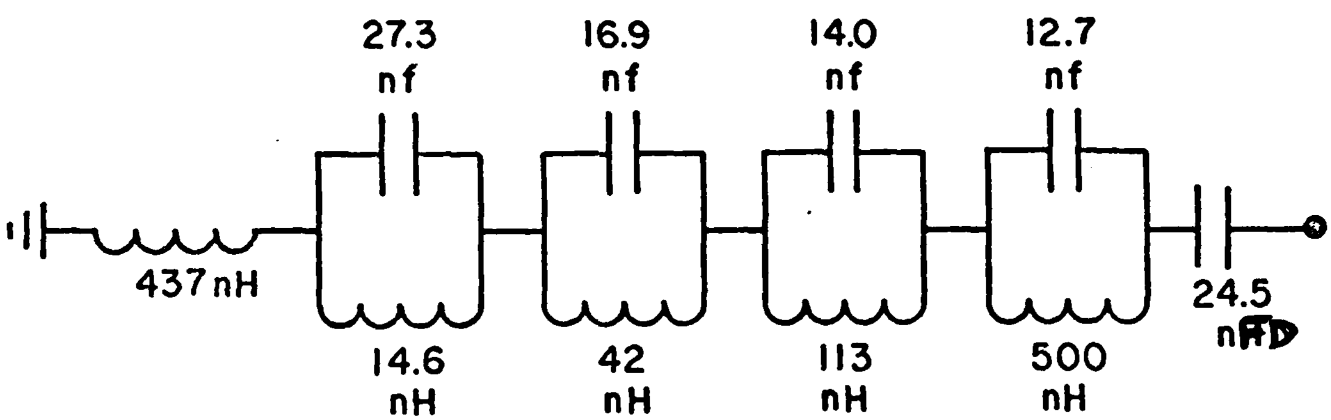
ESTART FILE? (Y/N)

DY.
T

1/07. 13.55.17.
DIDLE



C NETWORK



A NETWORK

K 9083

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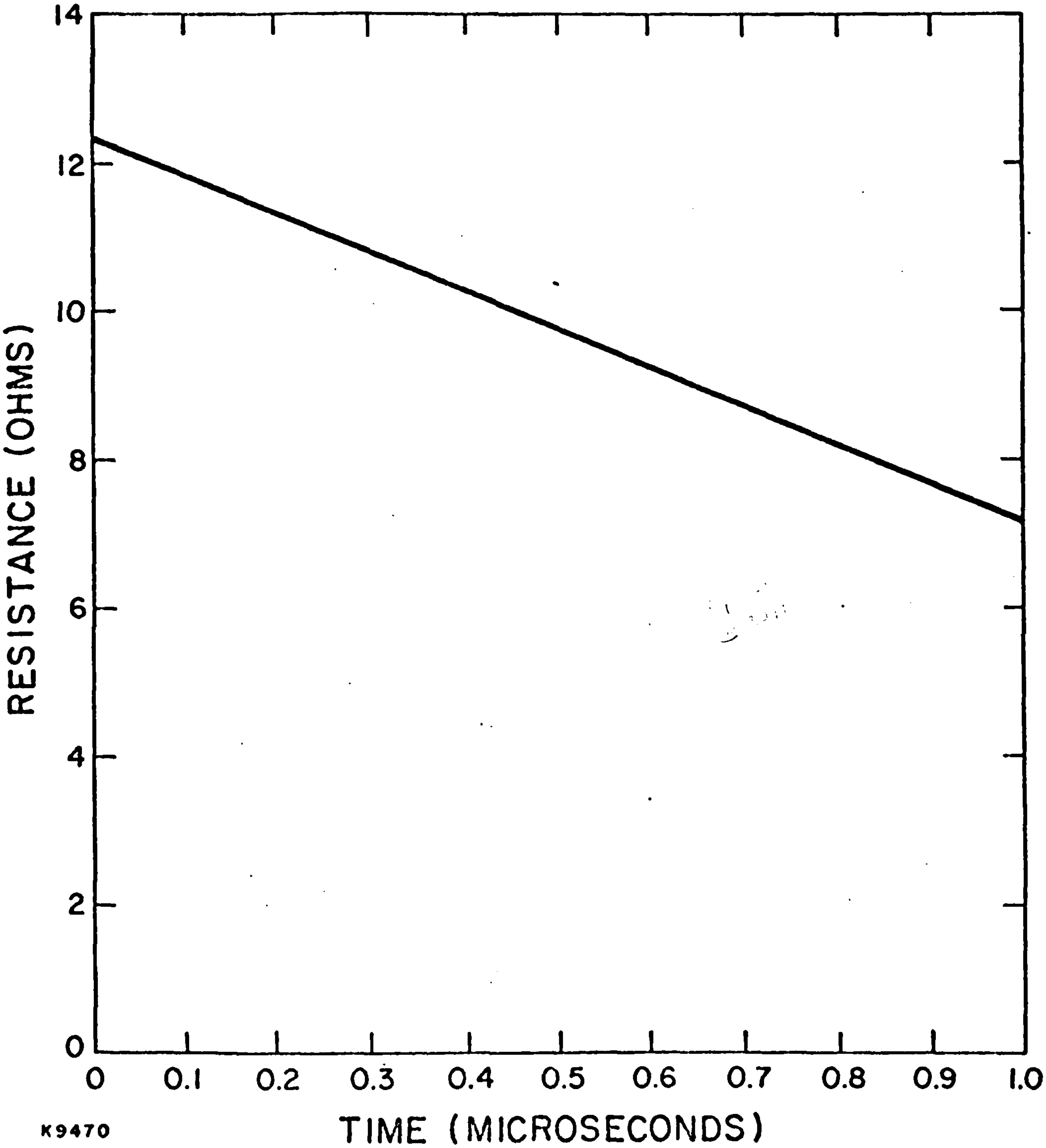
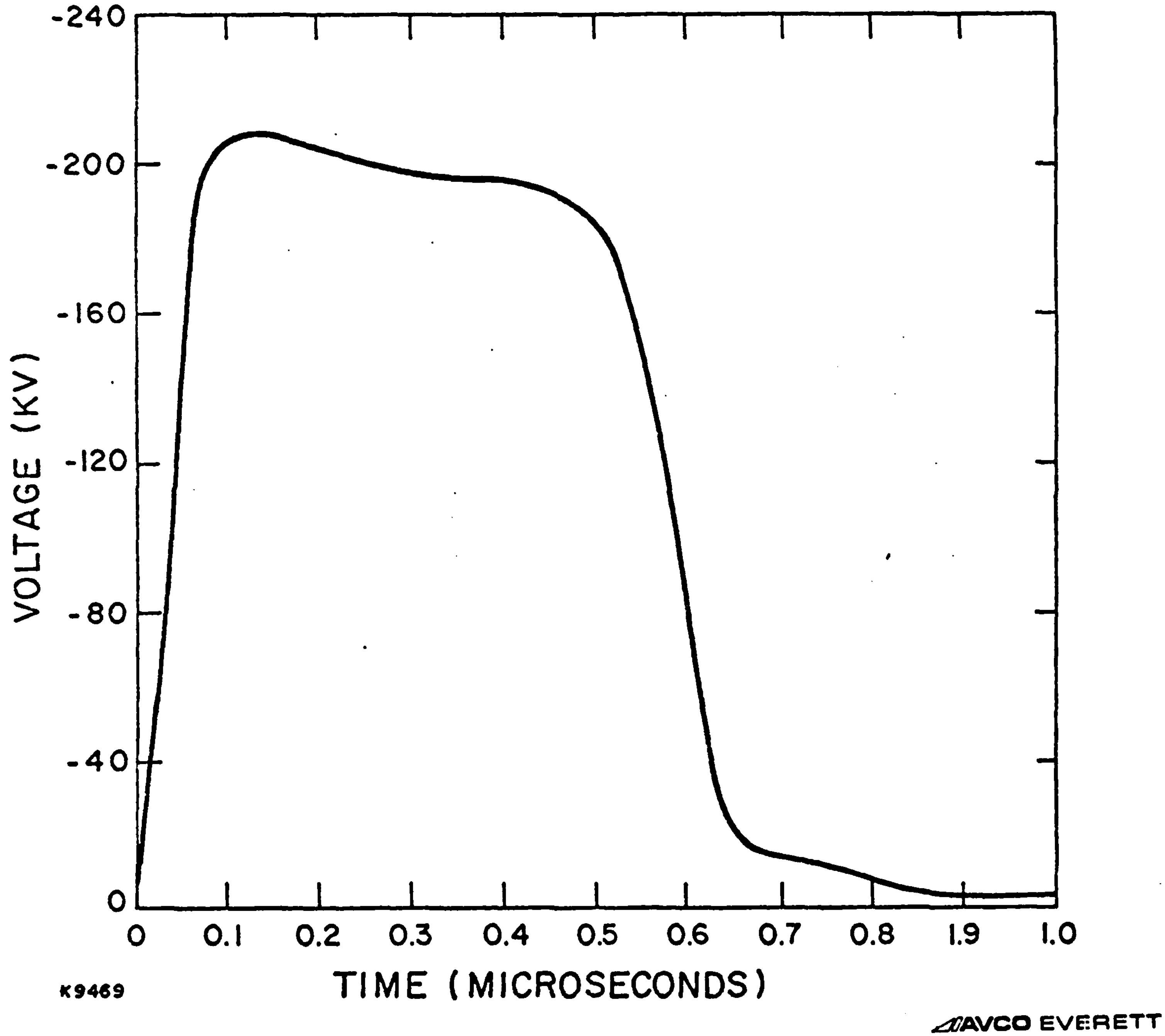
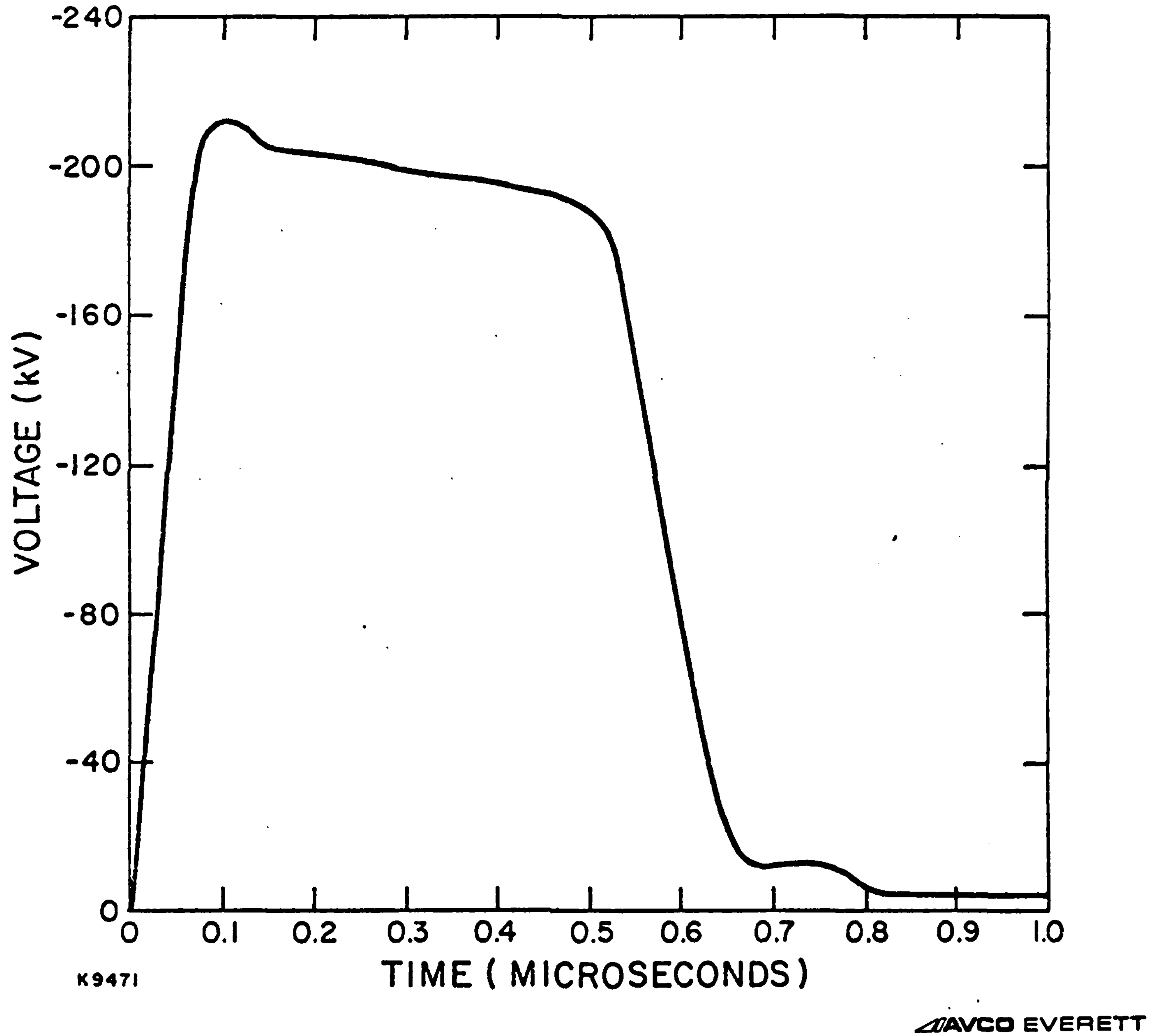


K9470

AVCO EVERETT


-240
-200
-160
-120
-80
-40
0
VOLTAGE (KV)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1.9
1.0
TIME (MICROSECONDS)
K9469
AVCO EVERETT


-240
-200
-160
-120
-80
-40
0
VOLTAGE (kV)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
TIME (MICROSECONDS)
K9471
AVCO EVERETT

PFN/SWITCH REQUIREMENTS

- VOLTAGE HOLD-OFF: 500 KV
- ENERGY 1640/J PULSE @ 30 PPS (1.5 SEC)
- PULSE CHARGING TIME: 30μS
- PULSE DISCHARGE TIME: 0.5 μSEC

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REPETITIVE PULSE POWER SYSTEM

- CONSTRUCTION DETAILS
- STATUS
- SCHEDULE

V. N. MARTIN

AVCO EVERETT

STATUS a/o 3/5/84

	% COMPLETE
• ELECTRICAL DESIGN	95
• LAYOUTS + MECHANICAL DETAILS	95
• MAJOR HV voltage COMPONENTS	85
• SUBASSEMBLIES	90
• TANK INSTALLATION	50

STATUS: COMPLETED SUBASSEMBLIES

- T.I.G. (trigger isolated gap) HV TRIGGER DRIVE CHASSIS
- CHARGING THYRATRON MODULE
- INTERMEDIATE CAPACITOR ASSEMBLY (10 - .11 mf Capacitors)
- PFN CAPACITORS
- T.I.G. SUPPORT STRUCTURE

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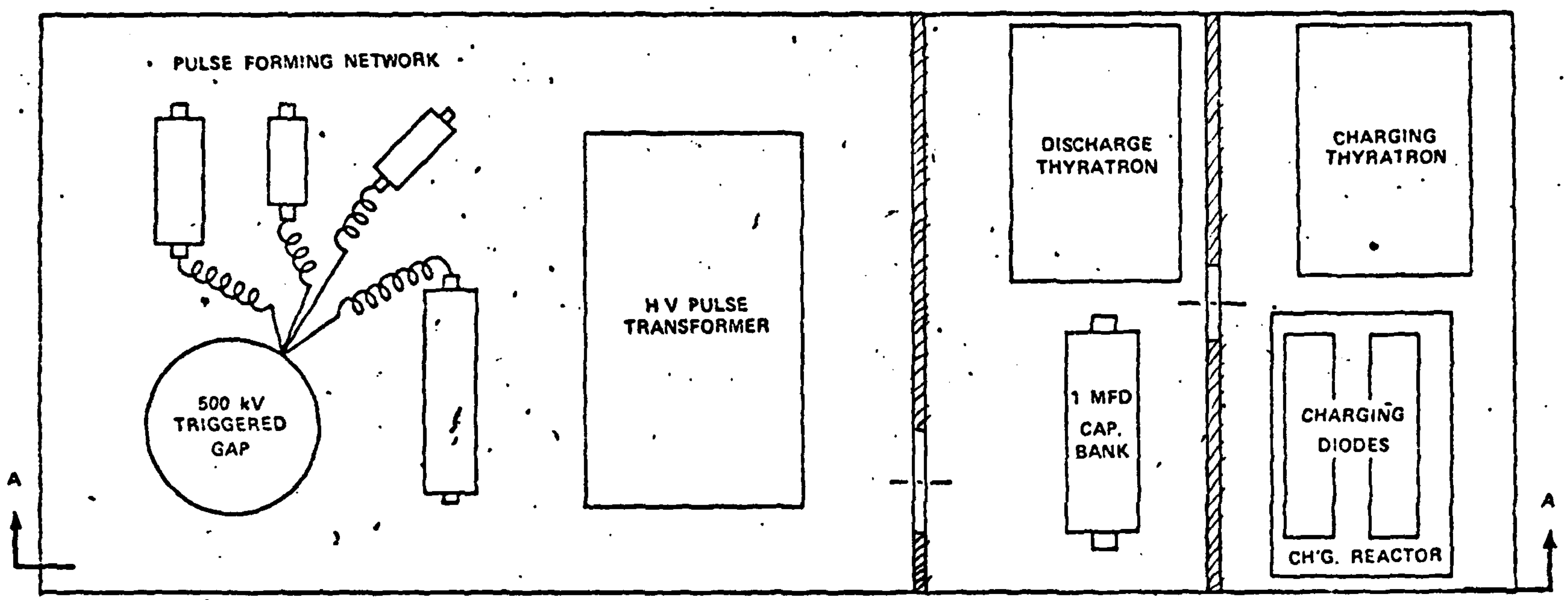
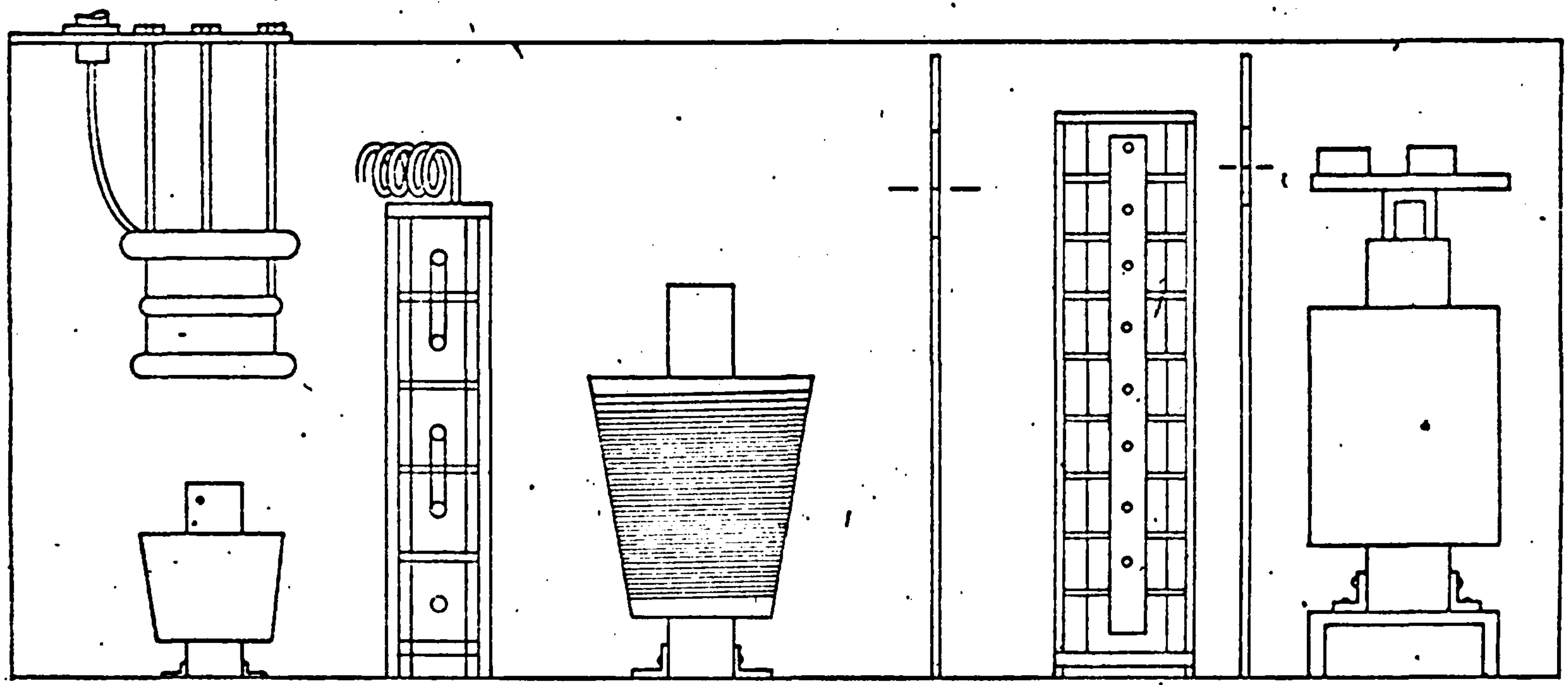


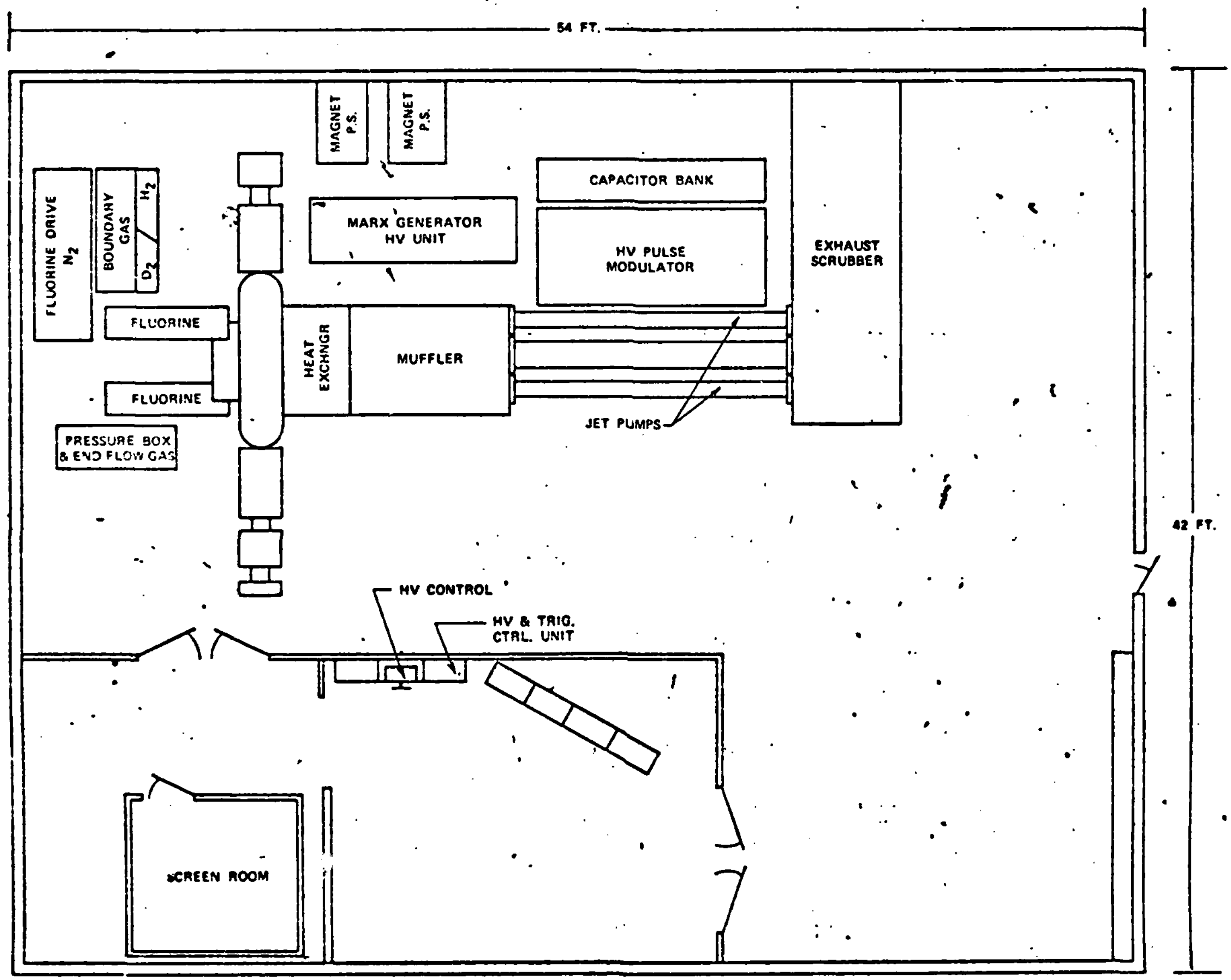
K9467

AVCO EVERETT



K9466

AVCO EVERETT



#9468

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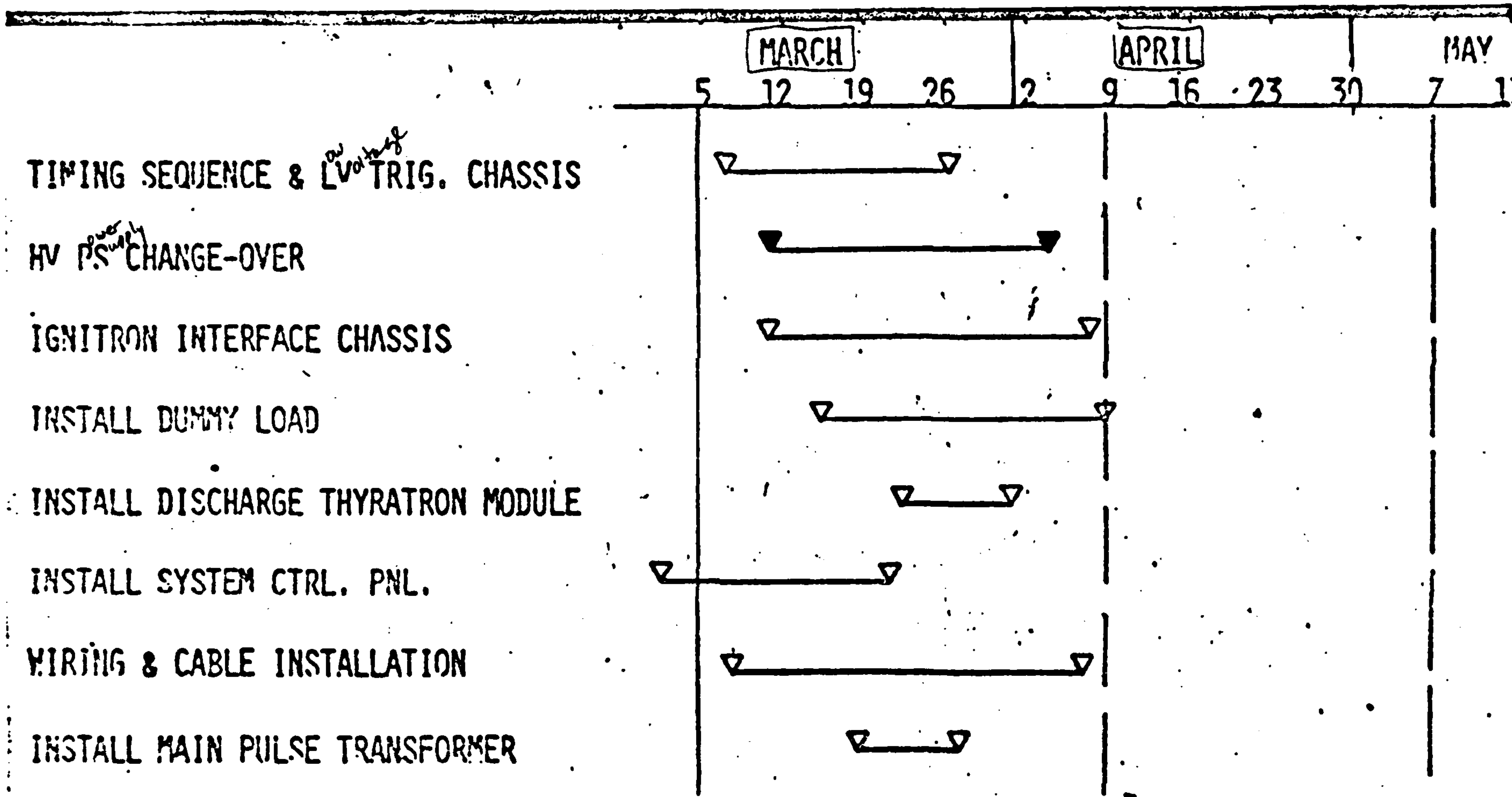
EQUIPMENT SCHEDULE TO COMPLETION



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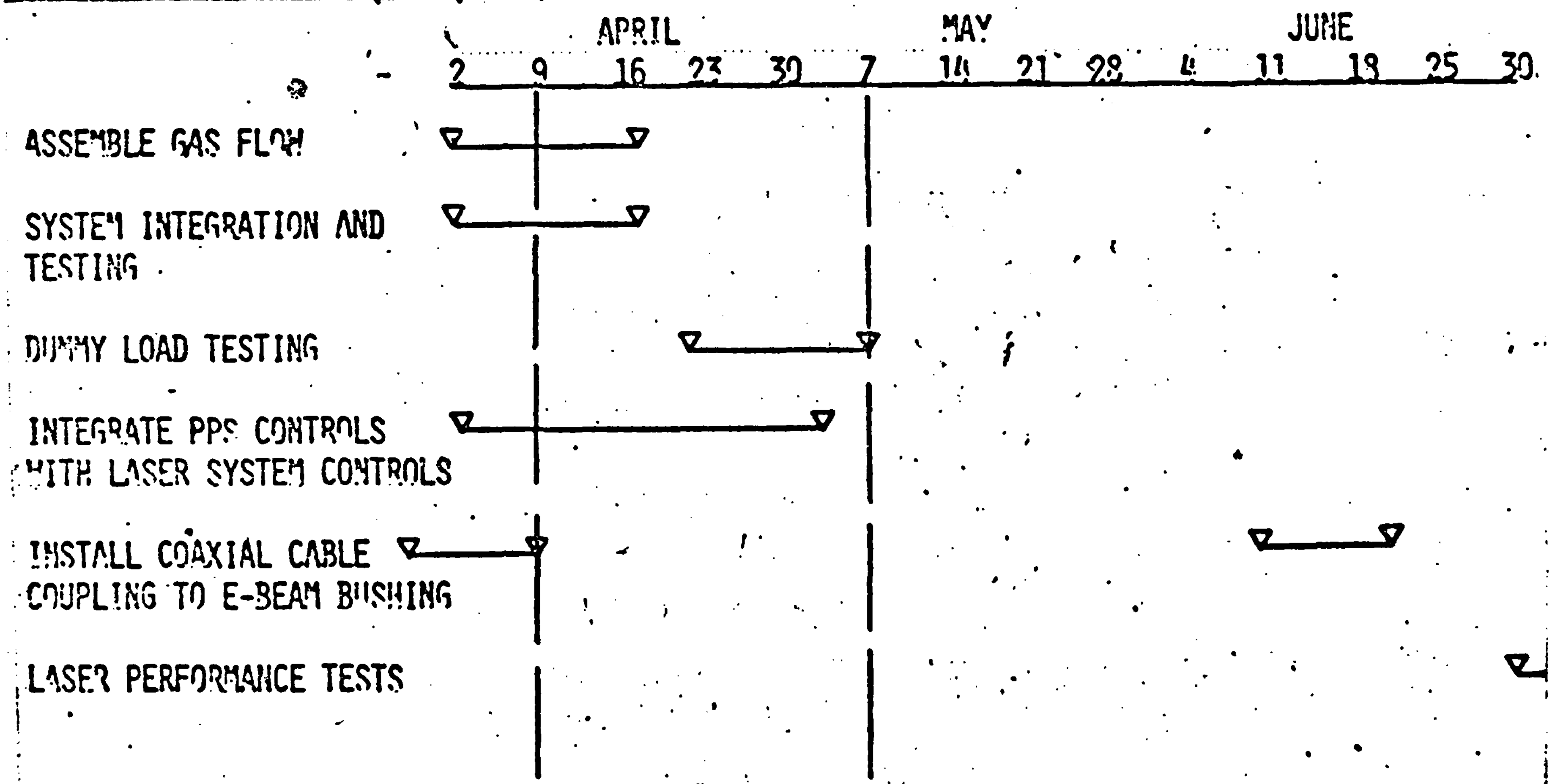
SYSTEM INTEGRATION AND TESTING



AVCO EVERETT

PULSED CHEMICAL LASER TECHNOLOGY DEVELOPMENT

TEST PLAN

SINGLE PULSE DIAGNOSTIC TESTING

Contract No. DAAH01-83-C-0282

Prepared For

Department of the Army

U.S. Army Missile Command

Redstone Arsenal, Alabama

Prepared By

James P. Moran

Avco Everett Research Laboratory

Everett, Mass.

TABLE I: TEST PLAN: TASK III - SINGLE PULSE TESTING

Shift Date Scale One Week to Left

2/20	2/27	3/5	3/12	3/19	3/26	4/2	4/9	4/16	4/23	4/30	5/7	5/14	5/21	5/28	6/4	6/11	6/18	6/25	7/2
2/24	3/2	3/9	3/16	3/23	3/30	4/6	4/13	4/20	4/27	5/4	5/11	5/18	5/25	6/1	6/8	6/15	6/22	6/29	7/6

A GAS HANDLING

A1 TEST JET PUMP WITH CAVITY FLOW

A2 INSTALL SINGLE PULSE FLUIDIC VALVE DRIVE

A3 TEST FLUIDICS, p_c = 1.0 ATM

A4 TEST FULL FLOW, p_c = 1.0 ATM, 0.5 ATM

Have Not Done!

B FLUORINE GAS HANDLING

B1 INSTALL F_2 SUPPLY GAS CLEANUP

B2 INSTALL HF-HCl PLUMBING

B3 SHAKE DOWN F_2 GAS HANDLING

C MAIN LASER OPTICS

C1 INSTALL LASER OPTICS AND CALORIMETER

C2 INSTALL LASER PULSE SHAPE DETECTOR

C3 SHAKE DOWN CALORIMETER DIAGNOSTICS

C4 SHAKE DOWN LASER ALIGNMENT OPTICS

D SINGLE PULSE ELECTRON BEAM

D1 PUT CARBON FELT ON NEW CATHODE

D2 TEST TRANSMISSION OF OLD CATHODE, 1/2-IN. FOIL BAR SPACING

D3 INSTALL NEW CATHODE

D4 TEST NEW CATHODE TRANSMISSION, 1/2-IN. FOIL BAR SPACING

D5 TEST NEW CATHODE, FOIL BARS REMOVED

E LASER PERFORMANCE MEASUREMENTS

E1 TEST DF LASER 1.0 ATM 20 F_2, 6 D_2, 1 O_2, 73 He Baseline Navy

E2 TEST DF LASER 0.5 ATM, 1.0 ATM, 20 F_2, 6 D_2, 1 O_2 73 He

E3 DF LASER PERFORMANCE MEASUREMENTS, COMPOSITE

E4 CO_2 LASER PERFORMANCE MEASUREMENTS

ANCHOR PERFORMANCE

IMPROVE ELECTRIC. EF.F.

DF: ENERGY PULSE SHAPE INITIATION SPECTRA

DF: ENERGY PULSE SHAPE INITIATION SPECTRA GAIN

Conversion to CO_2

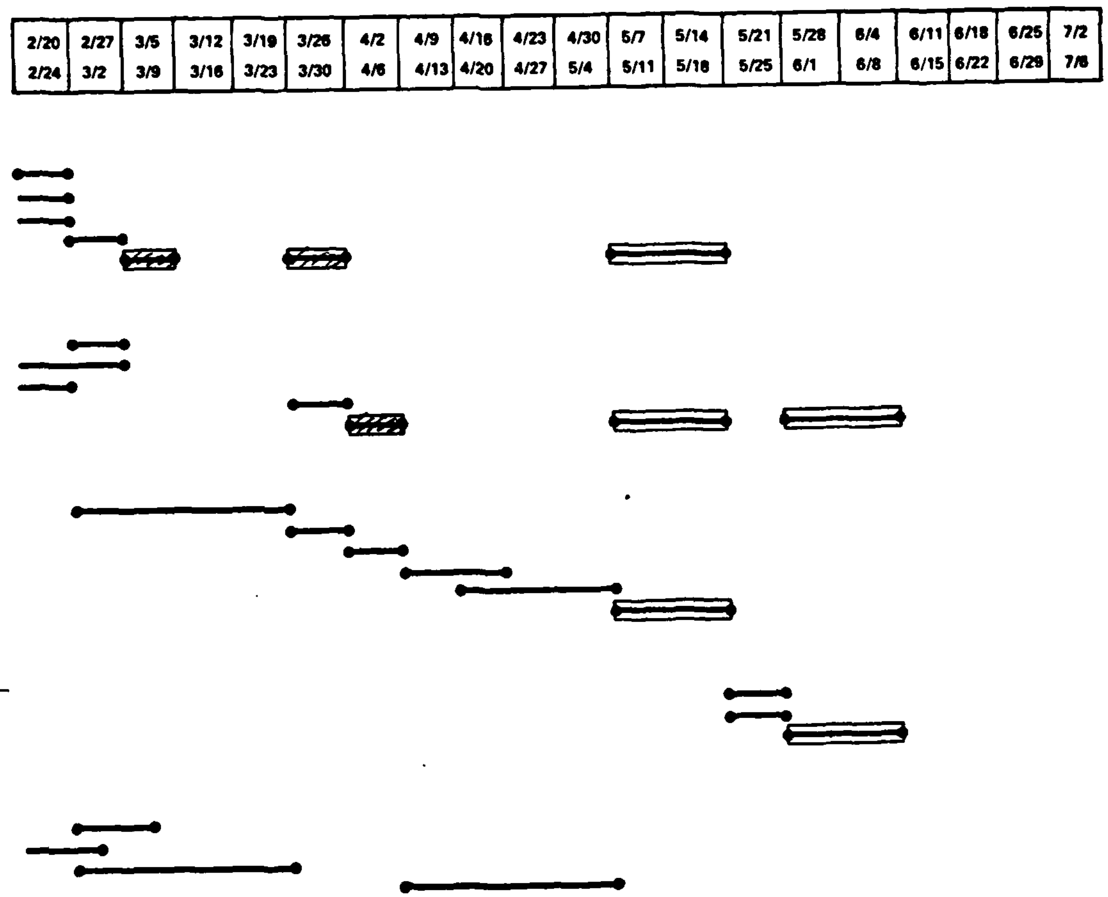
CO_2 ENERGY PULSE SHAPE SPECTRA

Conversion to RP

DF REP. PULSE SYSTEM SHAKE DOWN

L2981

TABLE I: TEST PLAN: TASK III - SINGLE PULSE TESTING (Continued)



F FLUORINE ATOM PRODUCTION MEASUREMENTS
F1 FABRICATE F-ATOM REFERENCE AND TEST LEGS
F2 SHAKE DOWN LUMONICS DF LASER
F3 INSTALL F-ATOM CONVEYANCE OPTICS
F4 SHAKE DOWN F-ATOM DETECTORS
F5 MEASURE F-ATOM FORMATION

G TIME INTEGRATED LASER SPECTRAL MEASUREMENTS, DF
G1 INSTALL SPECTROMETER
G2 FABRICATE FILM HOLDER
G3 INSTALL FLASH LAMP
G4 IMPLEMENT LASER/SPECTROMETER ALIGNMENT
G5 MEASURE LASER $\int$ DF (λ, t) dt

H TIME RESOLVED LASER SPECTRAL MEASUREMENTS, DF
H1 OBTAIN DF (λ, t), CO_2 (λ, t) DETECTORS (10)
H2 INSTALL ONE COMPLETE DF (λ, t) DATA CHANNEL
H3 SHAKE DOWN ONE DF (λ, t) CHANNEL
H4 INSTALL DF (λ, t) DETECTOR ARRAY
H5 INTEGRATE DF (λ, t) WITH DATA ACQUISITION
H6 MEASURE DF (λ, t) - TIME RESOLVED SPECTRA

I TIME RESOLVED LASER SPECTRAL MEASUREMENTS, CO_2
I1 MODIFY CALORIMETER AND WINDOW FOR CO_2 (λ, t)
I2 MODIFY SPECTROMETER FOR CO_2 (λ, t)
I3 MEASURE CO_2 (λ, t) - TIME RESOLVED SPECTRA

J DATA ACQUISITION SYSTEM
J1 IMPLEMENT 2-CHANNEL A/D DATA ACQUISITION
J2 FINALIZE SELECTION OF DATA ACQUISITION SYSTEM
J3 OBTAIN DATA ACQUISITION SYSTEM
J4 IMPLEMENT DATA ACQUISITION SYSTEM

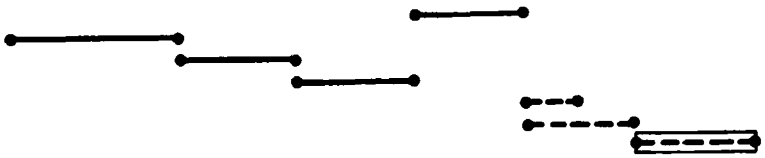
L2984

TABLE I: TEST PLAN: TASK III - SINGLE PULSE TESTING (Continued)

2/20	2/27	3/5	3/12	3/19	3/26	4/2	4/9	4/16	4/23	4/30	5/7	5/14	5/21	5/28	6/4	6/11	6/18	6/25	7/2
2/24	3/2	3/9	3/16	3/23	3/30	4/6	4/13	4/20	4/27	5/4	5/11	5/18	5/25	6/1	6/8	6/15	6/22	6/29	7/6

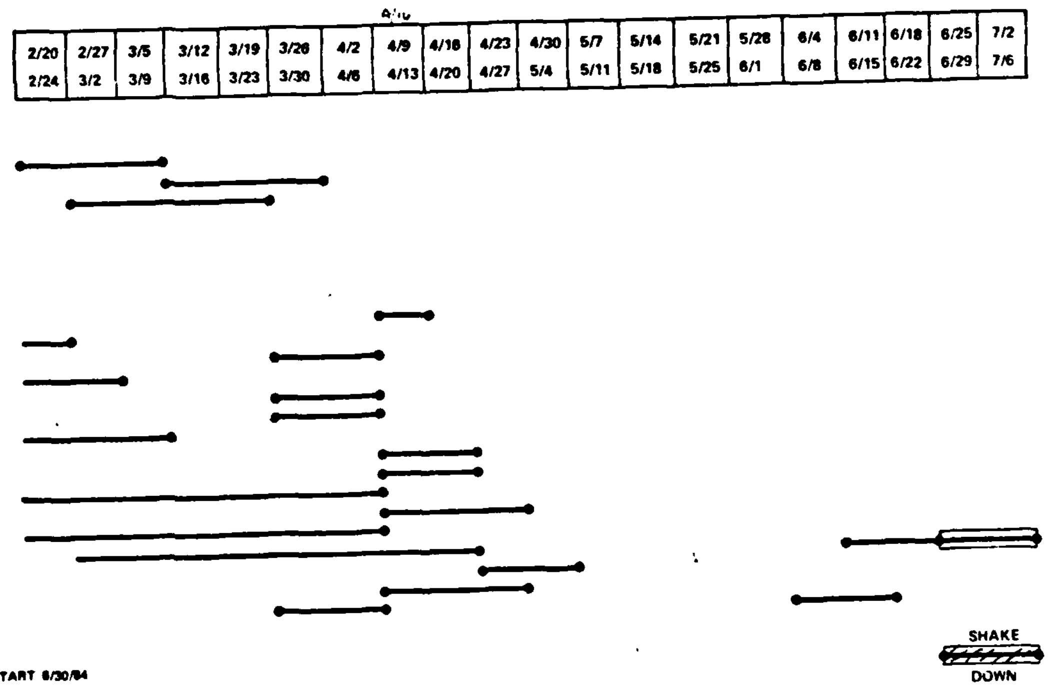
K TIME DEPENDENT GAIN MEASURMENTS, DF

K1 INSTALL PROBE LASER GAS SUPPLIES
K2 OBTAIN PROBE LASER LINE SELECTIVE OPTICS
K3 ASSEMBLE LASER OPTICS
K4 SHAKE DOWN FLASHLAMPS
K5 INSTALL PROBE LASER CONVEYANCE OPTICS
K6 SHAKE DOWN GAIN MEASUREMENT DETECTORS
K7 MEASURE GAIN DF (λ,t)



L2982

TABLE II: TEST PLAN: TASK III - REPETITIVELY PULSED TESTING



L E-BEAM FOIL, REPETITIVE PULSE OPERATION
L1 MODIFY FOIL SUPPORT STRUCTURE FRAME
L2 FABRICATE FOIL SUPPORT BARS
L3 OBTAIN BACKUP 4 MIL KAPTON/1.0 MIL A FOIL
L4 TEST NEW FOIL STRUCTURE TRANSMISSION, 3/8-IN. FOIL BAR SPACING
L5 TEST NEW FOIL STRUCTURE, BURST MODE REP PULSE

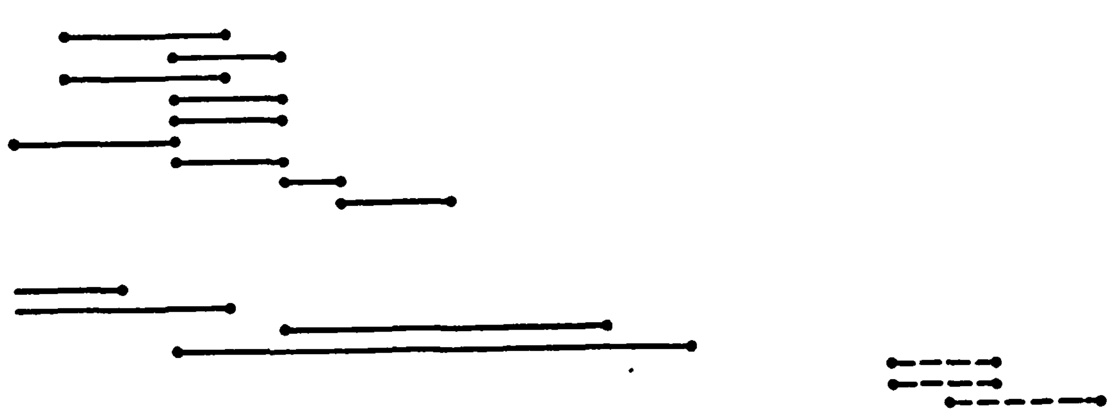
M REPETITIVE PULSE POWER SYSTEM
M1 COUPLE DC POWER SUPPLY TO ENERGY STORAGE CAPACITORS
M2 ASSEMBLE CHARGING THYRATRON MODULE
M3 ASSEMBLE CHARGING REACTOR SYSTEM
M4 ASSEMBLE DISCHARGE THYRATRON MODULE
M5 ASSEMBLE INTERMEDIATE STORAGE CAPACITOR SYSTEM
M6 INSTALL HV PULSE TRANSFORMER AND TRIGGER TRANSFORMER
M7 ASSEMBLE PULSE FORMING NETWORK
M8 INSTALL MAIN SPARK GAP AND TRIGGER ISOLATION GAP
M9 INSTALL DUMMY LOAD
M10 COMPONENT CHECKOUT
M11 ASSEMBLE GAS FLOW CONTROL
M12 ASSEMBLE SYSTEM CONTROLS AND TIMING AND DIAGNOSTICS
M13 SYSTEM INTEGRATION
M14 TEST TO DUMMY LOAD
M15 INTEGRATE PPS CONTROLS WITH LASER SYSTEM CONTROLS
M16 INSTALL COAXIAL CABLE COUPLING TO E-BEAM BUSHING

N LASER PERFORMANCE MEASUREMENTS, REPETITIVE PULSE TESTS START 6/30/84
N1 DF LASER PERFORMANCE
N2 CO_2 LASER PERFORMANCE

L2663

TABLE III: TEST PLAN: AERL-IRAD: REPETITIVELY PULSED TESTING

2/20	2/27	3/5	3/12	3/19	3/26	4/2	4/9	4/16	4/23	4/30	5/7	5/14	5/21	5/28	6/4	6/11	6/18	6/25	7/2
2/24	3/2	3/9	3/16	3/23	3/30	4/6	4/13	4/20	4/27	5/4	5/11	5/18	5/25	6/1	6/8	6/15	6/22	6/29	7/6



O E-BEAM FOIL ENVIRONMENT SIMULATOR
O1 ASSEMBLE FLOW TRAIN
O2 ASSEMBLE GAS SUPPLY AND CONTROL PLUMBING
O3 BENCH TEST FLUIDIC VALVES
O4 ASSEMBLE VALVING AND MIXER
O5 ASSEMBLE SPARK PLUGS AND IGNITION CIRCUITRY
O6 FABRICATE FOIL SUPPORT STRUCTURE ASSEMBLY
O7 INSTALL FLOW AND TEMPERATURE DIAGNOSTICS
O8 SYSTEM SHAKE DOWN
O9 TEST CANDIDATE REP PULSE FOILS

* P MECHANICAL D_2 VALVING
P1 COMPLETE VALVING DESIGN
P2 DESIGN VALVE DRIVE TRAIN AND TIMING
P3 FABRICATE VALVES
P4 OBTAIN AND ASSEMBLE DRIVE TRAIN COMPONENTS
P5 MODIFY PCL GAS HANDLING TO ACCOMMODATE VALVES
P6 INSTALL MECHANICAL VALVES
P7 TEST MECHANICAL VALVE PERFORMANCE

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* Fluidic valving applicable to high rep rate application. 25 Hz or below may lend itself more applicable to mechanical valves.

TABLE IV. TASK III SINGLE PULSE TESTING – TEST MATRIX

SERIES	DESCRIPTION	PARAMETER	F_2 % OR ATM.	D_2 %	O_2 %	DILUENT %	HF %	CO_2 %	PRESSURE TORR.	INITIATION STRENGTH μ COUL/CM^2
3/5–3/9	SHAKE DOWN SYSTEM IMPLEMENT F-ATOM DIAGNOSTICS		20	6	1	He 73	MIN. VS. SUPPLIED	0	760	1.5
3/19–3/23	SHAKE DOWN SYSTEM WITH CATHODE MODIFICATIONS		20	6	1	He 73	MIN.	0	200-760	1.5-3.0
3/26–4/6	LASER PARAMETRICS He REMOVAL IMPLEMENT TIME INTEGRATED SPECTRA		0.20	0.06	AS REQUIRED	He–0.73 –0.0	MIN.	0	210-760	3.0
5/7–5/18	LASER PARAMETRICS ALTERNATE DILUENTS IMPLEMENT TIME RESOLVED SPECTRA		0.20	0.06	AS REQUIRED	N_2–0.73 –0.00	MIN.	0	210-760	3.0
			0.20	0.06	AS REQUIRED	NF_3–0.24 –0.00	MIN.	0	210-400	3.0
5/28–6/8	LASER PARAMETRICS DF/CO_2		0.20	0.06	AS REQUIRED	0	MIN.	0–0.73	210-760	3.0
			0.20	0.06	AS REQUIRED	NF_3–0.24 –0.0	MIN.	NOM. 0.2	360-540	

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END

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